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Evaluation of a Non-Nuclear Soil Density Gauge on Fine-Grained Soils

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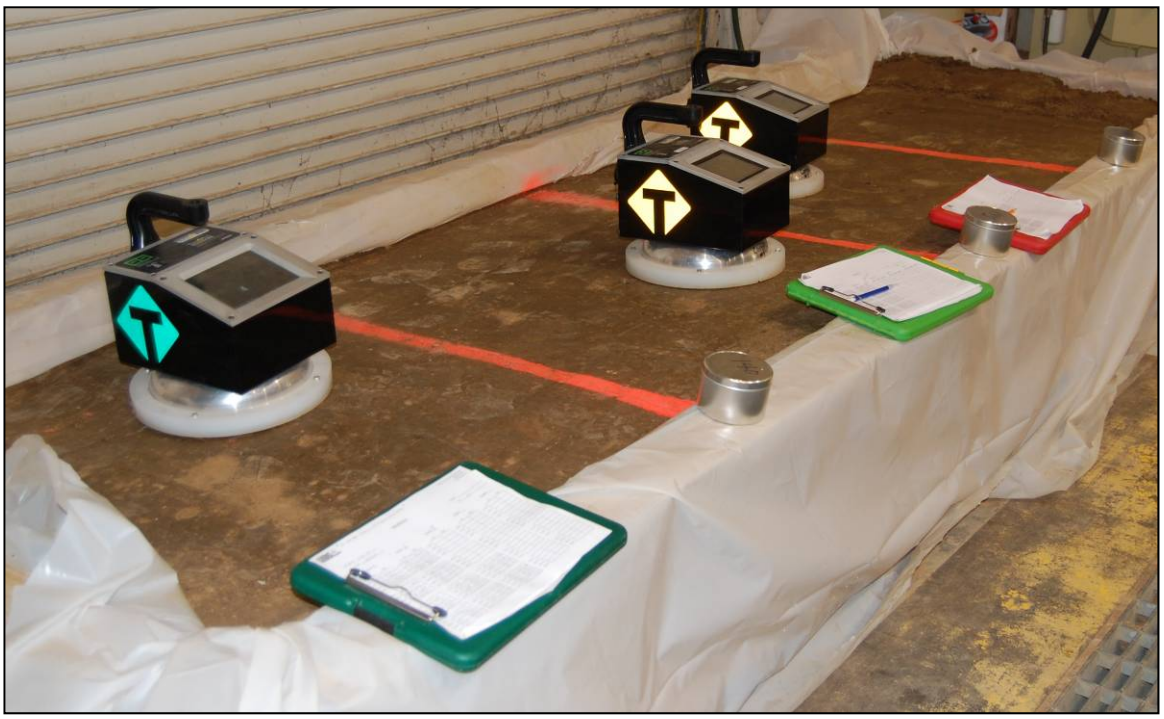
May 2013



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Final report

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Abstract

This report presents results from an evaluation of a non-nuclear soil moisture-density gauge, the Soil Density Gauge (SDG 200), tested on a series of 16 different fine-grained soils. If the results were successful, the device would serve as a replacement to the standard nuclear moisture-density gauge. Results from a standard nuclear moisture-density gauge were used for comparison.

Results of the tests are presented and include comparisons of the dry densities obtained from the SDG and the nuclear gauge. Correlations between the two devices showed a strong dependence on plasticity characteristics to distinguish among soil types. The lack of internal calibration for fine soils demonstrated poor correlation between moisture conditions for a given soil. Similar to SDG studies on coarser soils, the proper response from the SDG for fine-grained soils requires calibration of the dry density using at least one independent density sample obtained in the field with an alternative device such as a sand cone or a nuclear moisture-density gauge.

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Preface

The US Army Engineer Research and Development Center (ERDC) was tasked by the US Army Tank-Automotive and Armaments Command (TACOM) to evaluate a non-nuclear gauge for measuring soil density and moisture content. The research was conducted by personnel in the ERDC Engineering Systems and Materials Division (ESMD), Geotechnical and Structures Laboratory (GSL). Dr. Ernest S. Berney IV, Airfields and Pavements Branch (APB), ESMD, was the program manager for this project.

The principal investigator for this study was Mariely Mejías-Santiago, APB, who was assisted in the preparation of this report by Chase T. Bradley, APB. Other ESMD personnel who assisted in this research effort were L. Webb Mason, Adam F. Logue, Joseph M. Bonelli, Davon S. Mims, John L. Newton, Blake Andrews, and James Rowland, all of APB, and Elizabeth A. McDevitt, Concrete Materials Branch (CMB).

At the time of publication, Dr. Gary L. Anderton was Chief, APB; Chris Moore was Chief, CMB; Dr. Larry N. Lynch was Chief, ESMD; Dr. William P. Grogan was Deputy Director, GSL; and Dr. David W. Pittman was Director, GSL.

COL Kevin J. Wilson was Commander of ERDC. Dr. Jeffery P. Holland was the Director.

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Unit Conversion Factors

Multiply	By	To Obtain
cubic yards	0.7645549	cubic meters
feet	0.3048	meters
inches	0.0254	meters
pounds (force)	4.448222	newtons
pounds (force) per foot	14.59390	newtons per meter
pounds (force) per square foot	47.88026	pascals
pounds (force) per square inch	6.894757	kilopascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
square feet	0.09290304	square meters
tons (force)	8,896.443	newtons

1 Introduction

Background

The nuclear density gauge (NDG) is used to obtain the moisture content and density of soils and asphalt in preparation for and during construction projects. This instrument contains the radioactive materials Cesium and Americium, which subject it to restrictive requirements for its transport, use, and storage. Personnel trained in the handling of radioactive materials must always be present with the device, including during field work. This places severe logistics constraints within a mobile military. In theater, the gauge must be stored in a designated location, which identifies it as a priority target for the enemy and endangers personnel storing and retrieving these devices from the storage locations.

The US Army Tank-Automotive and Armaments Command (TACOM) recognized the need for and the benefits of eliminating the use of nuclear moisture-density gauges due to the restrictive requirements for their transport, use, and storage. The military is actively looking for a replacement for use in all other branches of the military. The requirement is for a single instrument that without the use of radioactive materials provides the density and moisture content of asphalt and soils.

In July 2008, TACOM issued a market investigation questionnaire in regard to the US Army's upcoming procurement of a Tester, Construction Materials, Moisture and Density. The objective of this survey was to secure a replacement for the nuclear gauge. Various devices were identified, including the Soil Density Gauge (SDG).

The SDG is an electrical impedance-based gauge that can provide soil density and moisture measurements. The gauge is primarily used as a quality control device during soil compaction. The gauge has limited distribution and requires research on improving its correlation database. The gauge's current database was developed by testing in a variety of coarse-grained soils. It was shown to produce density and moisture data comparable to the nuclear gauge in those soil types. However, its impedance spectra needed to be expanded to improve its resolution in fine-grained soils.

Another device that was identified was the Combined Asphalt and Soil Evaluator (CASE). The CASE is also a non-nuclear gauge that provides asphalt and soil density and moisture measurements in a single gauge and has been shown to work well on asphalt (Zhuang 2011). It also provides impedance spectra on soils similar to that of the SDG. However, the electromagnetic characteristics are sufficiently different from the current SDG that it requires a complete characterization on soils and empirical algorithms developed to be fully compliant with the range of soils of interest to the Army. At the time this study was conducted, the CASE was still on its prototype phase; and it was used only to collect data for database development.

The purpose of this project was to collect soil density and moisture content data with the SDG on 16 different fine-grained soils to expand its database and to develop correlations to improve estimation of soil density and moisture content.

Objectives

The objectives of this project were

- to conduct testing on 16 different fine-grained soils to obtain density and moisture content data using the SDG;
- to use the NDG nuclear gauge to obtain density values and the standard oven dry test to obtain moisture content values that could be compared with the measurements from the SDG;
- to collect data on the 16 soils using two CASE units for database development; and
- to make recommendations for improving the SDG's soil density and moisture content determinations in fine -grained soils

Scope

This study consisted of collecting soil density and moisture content readings from 16 types of fine-grained soils. Each soil was compacted inside a wooden box to a depth of 12 in. to create a soil sample of sufficient thickness to remove the influences of the box and or ground from instrument readings. Standard laboratory tests were conducted prior to the evaluation to determine the classification and compaction geotechnical properties of the soils. These properties were used as the input data for the SDG.

For each soil type, the soil was processed at three different moisture contents for testing: the soil being dry of the soil's optimum moisture content (OMC), at the OMC, and wet of the OMC. Then, after being prepared to the desired moisture content, the soil at each of the three moisture contents was compacted in the wooden box at three different levels of compaction (occasionally, based on soil type and moisture levels, only two levels of compaction were obtained), and data were collected at each compaction level. Thus, each soil type was tested at three different moisture levels; and for each moisture content, data were collected at three compaction levels. This provided a total of nine data sets per soil type.

Each data set consisted of four density and moisture readings that were taken at four different locations within the box. This resulted in 16 readings for each moisture content and compaction level for a total of 144 readings for each soil type. The CASE units were tested in the same locations.

For comparison, nuclear gauge density and moisture readings were also obtained at the same locations as the SDG and CASE readings, and soil samples were obtained at each test location for oven-dried moisture content determinations. All of these data collected were analyzed to determine the ability of the SDG to predict soil densities and moisture contents that were comparable to the nuclear gauge density values and the standard oven-dried moisture contents, respectively, on the soil types tested.

Report organization

This report is organized into five chapters starting with the introduction in Chapter 1, then in Chapter 2 a description of the materials and instruments evaluated. Chapter 3 presents the experimental procedures. The data analysis and discussion of the results are presented in Chapter 4, and conclusions and recommendations are presented in Chapter 5. Appendix A presents the soil characterization data and Appendix B presents the raw data collected with the instruments.

2 Materials and Test Devices

Soil materials tested

The soil materials used for this evaluation were fine-grained soils that are typically found in the southeastern and southwestern United States. Ten of the soil types were provided by the University of Houston. Five soils were found locally at the US Army Engineer Research and Development Center (ERDC) in test sections that had been constructed for previous projects. The last soil type (a high plasticity silt) was obtained from a quarry in north Mississippi.

Standard laboratory classification, index, and compaction tests were performed at the ERDC Materials Testing Center to determine the fundamental geotechnical properties of each of the 16 soil types. A list of these tests and the types of properties measured are in Table 1, and a summary of the properties is in Table 2. These test results are in Appendix A. The University of Houston provided soil properties that were determined by its laboratory, which varied slightly from the properties measured by ERDC; consequently, some soils were classified differently. The properties in Table 2 were used as the calibration input data for the SDG 200. The CASE units did not require calibration data input because the instruments did not have the algorithms to calculate density and soil moisture; these units were used only to collect data for frequency response database development.

Table 1. Standard laboratory tests.

Test Description	American Society for Testing and Materials Standard Method	Properties Measured
Grain Size Distribution	ASTM D 422	% Gravel % Sand % Fines Coefficient of Uniformity (C_u) Coefficient of Curvature (C_c)
Compaction (Standard Method)	ASTM D 698	Optimum Moisture Content (OMC) Maximum Dry Density (MDD)
Atterberg Limits	ASTM D 4318	Plastic Limit (PL) Liquid Limit (LL) Plasticity Index (PI)
Specific Gravity	ASTM D 854	Specific Gravity (G_s)
Bearing Ratio Test	ASTM D 1883	California Bearing Ratio (CBR)

Table 2. Geotechnical properties of soils used for evaluation.

Soil ID	Description	Atterberg Limits			Grain size (percent by weight)			C_u	C_c	MDD (pcf)	OMC (%)	G_s
		LL	PL	PI	Fines	Sand	Gravel					
CL-1	Sandy Clay	27	13	14	56.9	42.1	1	-	-	119.5	12.0	2.67
CL-2	Sandy Clay	39	11	28	64.1	34.0	1.9	-	-	115.5	14.2	2.72
CH-1	Sandy Clay[a]	41	14	27	61.8	37.0	1.2	-	-	110.9	16.5	2.72
SC-1	Clayey Sand	31	12	19	40.0	55.0	5	-	-	122.3	10.9	2.71
CH-2	Clay with sand	56	23	33	82.0	17.6	0.4	-	-	92.3	25.9	2.76
SC-2	Clayey Sand	25	14	11	32.1	66.0	1.9	-	-	122.8	11.3	2.69
CH-3	Sandy Clay	36	14	22	64.9	32.4	2.7	-	-	108.9	14.8	2.71
SC-3	Clayey Sand	28	10	18	49.6	49.7	0.7	-	-	122.7	10.3	2.70
CL-3	Sandy Clay	21	13	8	55.4	40.5	3.8	-	-	126.6	9.4	2.70
SC-4	Clayey Sand	36	12	24	35.1	61.3	3.6	-	-	122.2	11.1	2.70
CH-ERDC	Clay	73	24	49	95.1	4.9	0	-	-	85.7	24.6	2.76
MH	Silt	109	72	37	97.5	2.5	0	-	-	55.7	62.0	2.58
ML	Silt	No Plasticity			87.8	11	1.2	4.99	1.72	109.5	15.8	2.75
SP	Sand	No Plasticity			3.1	92	4.9	1.84	0.99	109.7	1.9	2.67
SM	Sandy Silt[b]	No Plasticity			50.3	47	2.7	37.21	0.20	121.8	10.0	2.71
SP-SC	Sand with Clay and Gravel	23	13	10	8.0	50.7	41.3	31.87	0.13	128.8	8.0	2.68

[a] Soil was classified as a CL by ERDC and as a CH by the University of Houston.

[b] Soil was classified as an ML by ERDC and as an SM by the University of Houston.

The compaction properties of maximum dry density (MDD) and optimum moisture content (OMC) shown in Table 2 were used to determine the appropriate moisture content levels for compaction and a desired percentage of maximum density for each soil.

Instruments

The list of instruments used in this study is presented in Table 3. The subsequent sections describe each instrument in more detail.

Table 3. List of instruments used in evaluation.

Instrument	Description	Manufacturer	Output Reading
Roadreader™ 3430	Nuclear Moisture-Density Gauge	Troxler Electronic Laboratories, Inc.	Wet and Dry Density % Moisture % Compaction
SDG 200	Soil Density Gauge	TransTech Systems, Inc.	Wet and Dry Density % Moisture % Compaction

Nuclear moisture-density gauge

The Troxler Roadreader™ nuclear moisture-density gauge, Model 3430, shown in Figure 1, was used for this evaluation. This gauge uses the interaction of gamma radiation with matter to measure density through direct transmission or backscatter. It determines the density of a material by counting the number of photons emitted by a Cesium-137 source that are read by the detector tubes in the gauge's base. In direct transmission, the source rod extends through the base of the gauge into a predrilled hole to position the source at the desired depth, a maximum of 12 in. Photons from the source travel through the material in the test area, collide with electrons present in the material, and reach the photon detectors in the gauge. During a backscatter measurement, the source is lowered near the surface of the test material in the same plane as the photon detectors. The gamma photons that enter the test material must be scattered at least once to reach the detectors in the gauge. Photons emitted from the source penetrate the test material, and the scattered photons are measured by the detectors. A backscatter reading measures material from the surface to a depth of approximately 4 in. (Troxler 2007).

A material with a high density increases the number of collisions between the gamma photons and the electrons present in the material. Therefore, the number of photons reaching the detector tubes is reduced. In short, the lower the number of photons reaching the detector tubes, the higher the material density. The opposite is true for material with a lower density; fewer collisions occur between the gamma photons and electrons present in the material. The more photons reaching the detector tubes, the higher the material density. A microprocessor in the gauge converts these counts into a density reading (Troxler 2007).

The moisture determination occurs in much the same way as the backscatter density reading. The Americium-241's beryllium source is located inside the gauge's base. Fast neutrons from this source enter the

Figure 1. Nuclear moisture-density gauge used for testing.

test material and are slowed by collisions with hydrogen atoms present in the material. The Helium 3 detector in the gauge's base counts the number of thermalized (slowed) neutrons. This number (known as the moisture count) is directly related to the amount of moisture in the tested area (Troxler 2007).

The nuclear moisture-density was used according to American Society for Testing and Materials (ASTM) (2010a) with a rod driven 6 in. into the ground to obtain moisture content and wet density. The maximum depth of influence was assumed to be 6 in. below the surface, based on manufacturer's recommendations.

Soil Density Gauge (SDG)

The SDG is an electrical impedance-based gauge manufactured by TransTech Systems, Inc., and is used as a quality control tool during soil compaction. The Model 200 (Figure 2), used in this evaluation, is equipped with a touch screen, a graphical menu interface, and a Global Positioning System (GPS). The device uses advanced electrical impedance spectroscopy (EIS) to make soil density and moisture content readings non-destructively.

Figure 2. SDG 200 (www.transtechsys.com).

As shown in the diagram in Figure 3, the non-contacting sensor in the SDG 200 consists of two rings: a central ring and an outer ring. The central transmit ring injects an electric field into the soil, and the response is received by the outer sensing ring. The density, or compaction level, is measured by the response of the SDG's electrical sensing field to changes in electrical impedance of the material matrix. Since the dielectric constant of air is much lower than that of the other soil constituents, as density/ compaction increases, the combined dielectric constant increases because the percentage of air in the soil matrix decreases. The SDG performs a calculation that uses the soil properties (MDD, OMC, grain size distribution, and Atterberg limits) as input data and the measurement data to report the soil's density and moisture content (TransTech Systems, Inc., 2011).

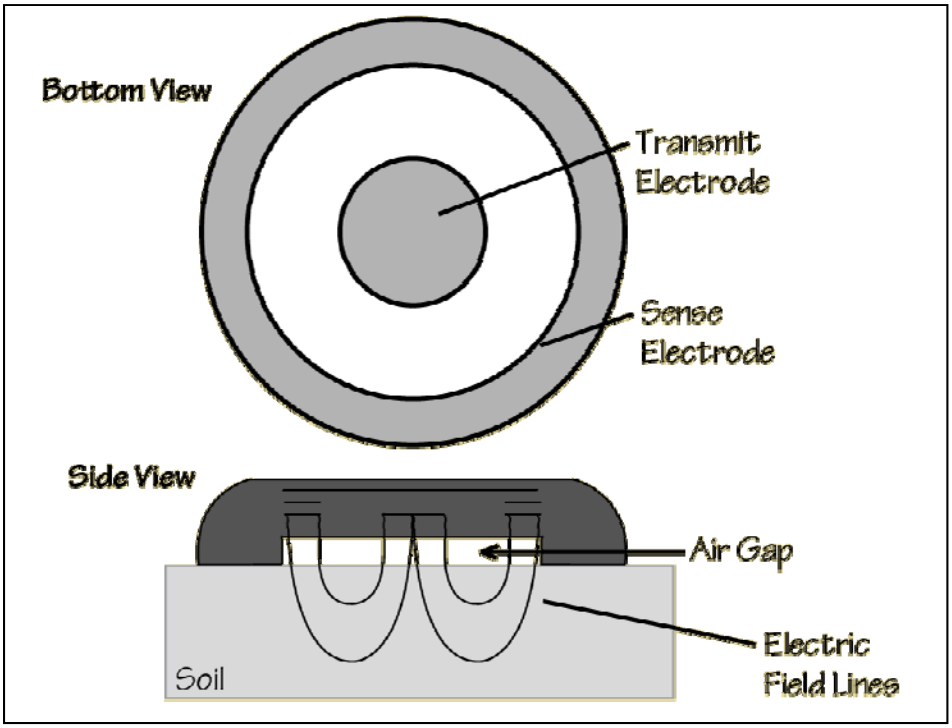

Figure 3. Configuration of the SDG 200 non-contacting sensor (www.transtechsys.com).

3 Experimental Procedures

The evaluation was conducted over a five-month period (October 2010 to February 2011). Soil density and moisture content measurements were obtained from the SDG and the nuclear moisture-density gauge on test sections consisting of soils compacted in wooden boxes. The construction of the test sections and the experimental procedures are described in the following paragraphs.

Test section construction

Each test section was contained in a wooden box 12 ft long, 3 ft wide, and 14 in. deep (Figure 4), housed within a climate-controlled building. The boxes were fabricated at ERDC with marine plywood for resistance to moisture and for support of the lateral loads generated by the compaction activity and the soil's weight. A plastic cover was placed at the bottom of each box to prevent the wood from absorbing any moisture from the soil and to maintain consistent moisture content within the soil.

Figure 4. Wooden box with plastic cover for moisture protection.

For each soil type, the soil was prepared at three different moisture contents for testing: dry of optimum moisture content, near optimum, and wet of optimum. Each soil was prepared to the desired moisture content by letting

it air dry or by wetting it with a hydro-seeder (Figure 5), depending on its moisture content at the time of preparation. A skid steer was used to mix the soil and distribute the moisture consistently, as shown in Figure 6. For test section construction purposes only, constant monitoring of the soil moisture content was performed by using the standard laboratory micro-wave oven procedure (ASTM2010c). Once the soil was at the desired moisture content, it was placed in the box in two lifts using a skid steer (Figure 7) or a bucket loader and shovels. Some of the soils, especially the high plasticity clays (CH), required the use of a tiller (Figure 8) to loosen the soil so that the moisture could be distributed more uniformly. The tiller was also used at the end of each moisture level test to loosen the soil and remove it from the box.

Each soil lift was placed loosely in approximately 8- to 9-in. -thick lifts and compacted to a 6-in.-thick lift. After compaction of the first lift, nuclear moisture-density gauge readings were obtained in accordance to ASTM (2010a) procedures. A certified operator at the center of the box ensured that the desired density was obtained before placing and compacting the second lift. The soil was compacted in two 6-in.-thick lifts to a final thick-ness of 12 in. About 1.8 yd^3 of soil was required to prepare each test section at each moisture level. Some of the soils were compacted with a plate compactor (Figure 9), and others (the finer and softer soils) were

Figure 5. Hydro-seeder used to wet the soils.

Figure 6. Skid steer used to mix the soils and distribute the moisture consistently.

Figure 7. Using a skid steer to place soil in the box.

Figure 8. Tiller used to loosen the soil during soil preparation.

Figure 9. Plate compactor.

compacted with the steel-wheel roller in Figure 10. A jumping jack tamper (Figure 11) was used in some cases to compact the edges. The test section was considered ready for testing when the second lift was compacted to the first compaction level.

Test procedures

For each soil, density and moisture content measurements were made at varying levels of compaction. Compaction data were recorded typically after two passes, four passes, and eight passes of the compactor, which correlated to a low, medium, and high density, respectively. In some instances, only two compaction levels could be obtained for a specific soil, resulting in only low- and high-density measurements. The number of passes to achieve the various levels of compaction varied among soils. Testing began once the second lift of soil was compacted to its first compaction level, after which measurements continued to be collected following each increased compaction level. The construction and test sequence that was used for testing each soil and the approximate time required to complete each task are in Table 4. The time required for completing each sequence varied for different soils because some soils required either longer or shorter periods of time to prepare them at the desired moisture content.

Figure 10. Steel-wheel roller compactor with a 1,000 lb capacity.

Figure 11. Jumping jack compactor.

Table 4. Construction and test sequence for each soil.

Day	Moisture Level	Task Description
1	1	– Prepare soil to the first moisture level.
		– Construct Lift 1 at approx. 95% of optimum density.
		– Record nuclear gauge measurements for quality control.
		– Construct Lift 2 and compact to first compaction level.
2		– Test Lift 2 using pattern in Figure 12 after passes 2, 4 and 8.
		– Conduct additional testing with impact instruments at the last compaction level.
3	2	– Prepare soil at second moisture level.
		– Construct Lift 1 at approx. 95% of optimum density.
		– Record nuclear gauge measurements for quality control.
		– Place Lift 2 and compact to first compaction level.
		– Test Lift 2 using pattern in Figure 12 after passes 2, 4 and 8.
4		– Additional testing with impact instruments at the last compaction level.
	3	– Prepare soil at third moisture level.
		– Construct Lift 1 at approx. 95% of optimum density.
		– Record nuclear gauge measurements for quality control.

Day	Moisture Level	Task Description
5		– Construct Lift 2 and compact to first compaction level.
		– Test Lift 2 using pattern in Figure 12 after passes 2, 4 and 8.
		– Additional testing with impact instruments at the last compaction level.
		– Prepare next soil.

The test pattern used to obtain data from each instrument at each soil compaction level is shown in Figure 12. The nuclear moisture-density gauge was located at the center (red dot) of each test area, and then four readings were obtained by rotating the gauge approximately 90 deg clockwise from the first reading position (red dashed lines). Then, four readings were obtained with the CASE units and the SDG 200 at locations 1, 2, 3, and 4 in the area between two consecutive reading positions of the nuclear moisture-density gauge. This was repeated at each test area (A, B, C, and D). It is important to note that the CASE and the SDG produced each of their readings by calculating the average of a set of readings taken in a cloverleaf pattern as shown in Figure 13.

Following each compaction effort, metal rods were inserted into the existing holes used for the nuclear gauge rod to allow the soil to be compacted around the rod for reuse in testing subsequent compaction efforts (Figure 14).

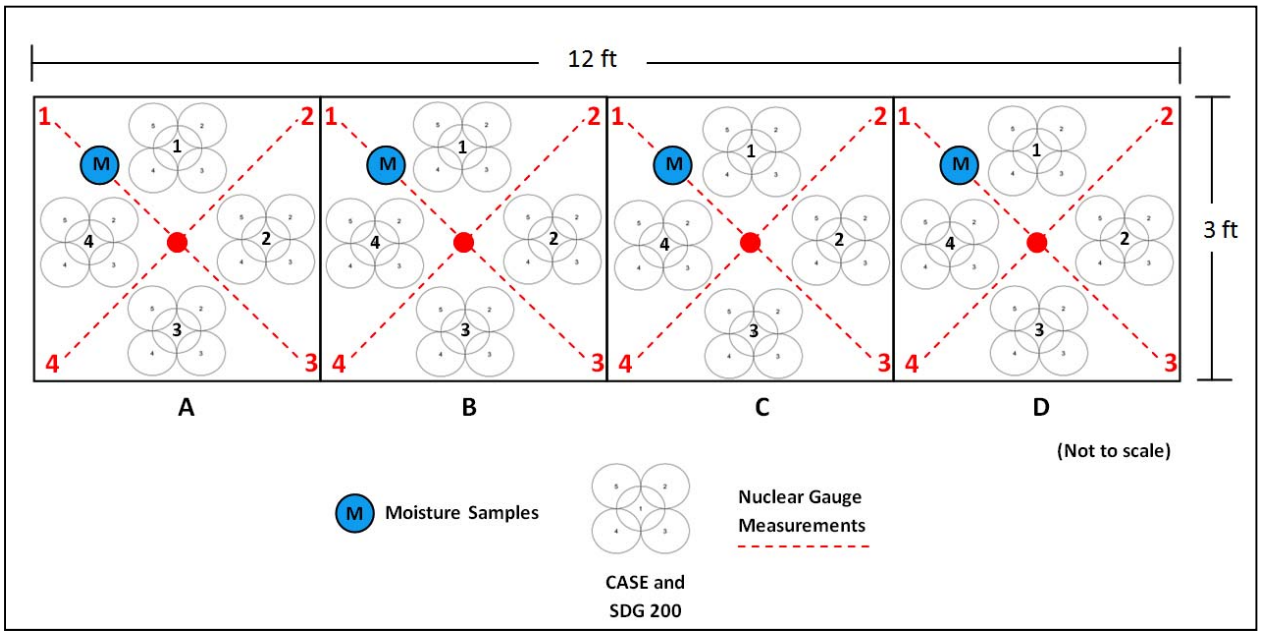

Figure 12. Test pattern for all the instruments.

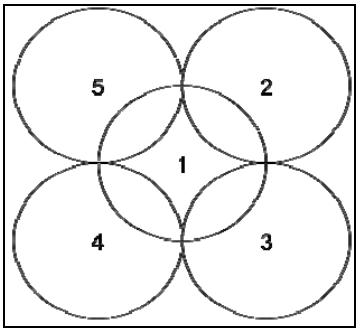

Figure 13. Clover-leaf pattern of readings of the non-nuclear gauges.

Figure 14. Metal rods placed at the nuclear gauge holes.

The reading log is listed in Table 5. Readings from the nuclear gauge were compared to readings from the non-nuclear gauges as follows. The average value of readings A-1 and A-2 from the nuclear gauge was compared to reading A-1-2 of the non-nuclear gauges, and so on, as reading A-1-2 covered a volume of soil between readings A-1 and A-2

One soil sample was obtained from each test location (A, B, C and D) for standard oven-dried moisture content determination following ASTM (2010b) guidance after testing was completed for each compaction level. These data were compared to the instruments' readings of moisture content.

Table 5. Reading log.

Test Area	Test Location	Reading ID	
		Nuclear Gauge	Non-Nuclear Gauges
A	1	A-1	A-1-2
	2	A-2	A-2-3
	3	A-3	A-3-4
	4	A-4	A-4-1
B	1	B-1	B-1-2
	2	B-2	B-2-3
	3	B-3	B-3-4
	4	B-4	B-4-1
C	1	C-1	C-1-2
	2	C-2	C-2-3
	3	C-3	C-3-4
	4	C-4	C-4-1
D	1	D-1	D-1-2
	2	D-2	D-2-3
	3	D-3	D-3-4
	4	D-4	D-4-1

4 Data Analysis and Results

Data were jointly collected with the nuclear moisture-density gauge, the SDG, and the two CASE units. Data collected with the nuclear moisture-density gauge and SDG could be correlated, as both returned direct values of moisture content and soil density. Of specific interest is the comparison of dry density values from each device. Comparisons of moisture content values from each device have already been performed by Berney, Kyzar, and Oyelam (2011). The CASE did not return direct values for comparison and was used only to collect data to support database development; therefore, it is not included in the following comparisons.

A multiple-linear regression approach was taken to determine the significance of the SDG internal parameters and soil properties acquired from laboratory testing to improve the accuracy of the dry density measured by the SDG. From the 16 soils documented in Table 2, 539 data points were obtained and are listed in their entirety in Appendix B. Table 6 lists the statistically relevant variables along with the correlation coefficients associated with each.

Table 6. Statistical variables and coefficients values for regression analysis.

Variable	r value	Coefficient	All Soils	All Soils	Fine	Coarse
Constant		a1	130.188	92.300	90.596	167.936
SDG Wet Density	0.261	a2	-0.320	0.124	0.132	-0.377
SDG Moisture Content	0.233	a3	1.068	-0.426	-0.101	1.434
C Value	0.289	a4	0.811	0.970	0.738	1.634
Plasticity Index (PI)	0.683	a5	-0.793	-0.118	-0.186	-0.647
Plastic Limit (PL)	0.810	a6	-0.647	-0.404	-0.486	-3.511
Dry Density Correction	0.792	a7*		0.698	0.645	2.638
		Overall r =	0.911	0.944	0.953	0.704
		r^2 =	0.83	0.89	0.91	0.50

* a7 uses a field density correction with alternate source (sand cone or nuclear gauge)

r = correlation coefficient

r^2 = coefficient of determination

The equation that relates these variables to the NDG dry density, γ_d, and from which the statistical coefficients were generated is as follows:

$$\gamma_{d\text{-}NDG}\,(pcf) = a1 + a2*SGD + a3*SGM + a4*C + a5*PI + a6*PL \quad \text{(Eq. 1)}$$

where

SGD = SDG's dry density
SGM = SDG's moisture content
C = parameter derived from the SDG's frequency spectrum
PI = soils' plasticity index
PL = soils' plastic limit

From this expression, the following figures demonstrate the improvement in predictive response for the SDG as the soil properties and internal variables are introduced. Figure 15 shows a comparison of the raw readouts between the SDG and NDG. Without any correction or consideration of soil properties or internal variables, the SDG has little correlation with the NDG for these fine-grained soils.

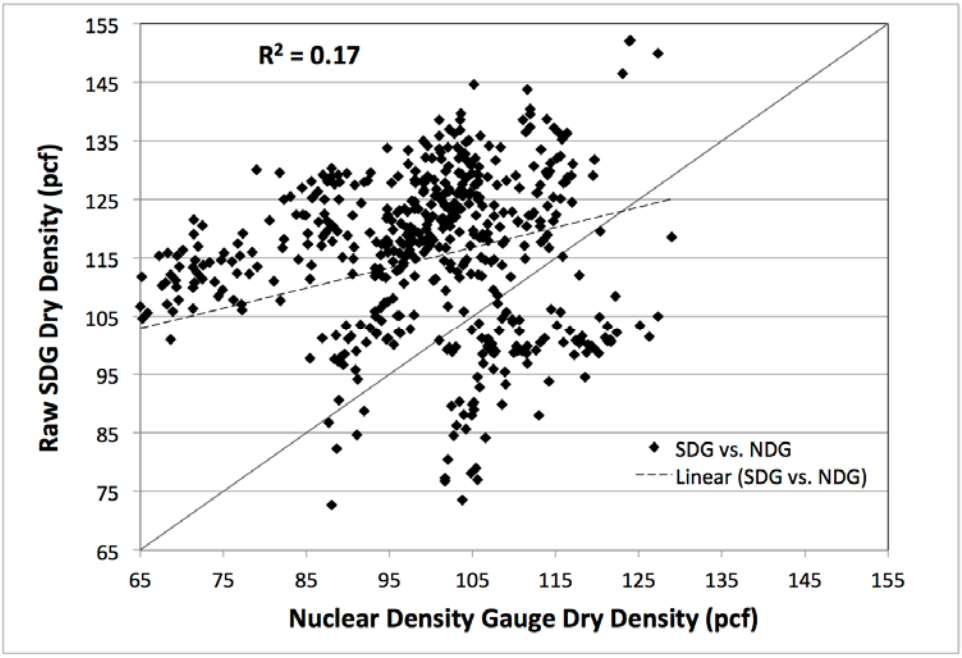

Figure 15. Direct comparison of NDG to SDG dry density as recorded by each instrument (no correction).

Figure 16 shows the increase in correlation when the internal variables of the SDG (wet density, moisture content, and frequency parameter, C) along with the plasticity of the soil are considered. The coefficient of determination rises from 17 percent to 83 percent. What is evident in this figure is the presence of horizontal banding in the data associated with

each different soil tested. This indicates that, while overall the variables account for the range of soils tested, the SDG still has difficulty distinguishing small changes in density for a single soil type with increasing passes during construction.

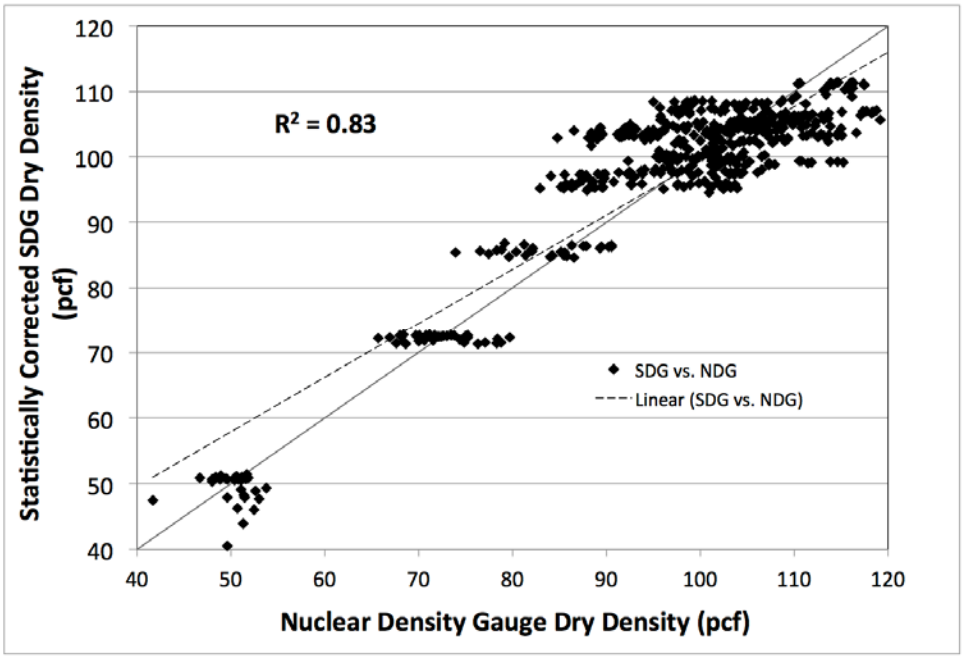

Figure 16. Comparison of NDG to SDG dry density with statistical correction applied.

To help reduce this banding issue, a calibration point was taken for each of the tested soils (COR). Numerically this involved taking a single random nuclear gauge dry density reading from each soil and calculating the dry density offset (by subtraction) between its value and the value the SDG returned at the same test location. This was set as a constant value for each soil and used as another statistical variable, a7, in Table 6 and Equation 2 as follows:

$$\gamma_{d\text{-}NDG}\,(pcf) = a1 + a2*SGD + a3*SGM + a4*C + a5*PI + a6*PL + a7*COR \quad \text{(Eq. 2)}$$

where

COR = numeric difference between one NDG's dry density reading and its companion SGD reading

Results of introducing this calibration point for each soil are shown in Figure 17. The coefficient of determination increases slightly from 83 percent to 87 percent, but more importantly, a decrease in banding is observed for each soil tested. However, a comparison between the two

devices for each soil individually shows a continued presence of banding as shown in Figures 18 and 19.

The tested soils were compacted at differing moisture contents to create the appearance of varying density for the same soil type. What is readily apparent from Figures 18 and 19 is that, for most soils, the SDG was unable to distinguish as much change in dry density as did the nuclear gauge from one moisture condition to the next. This is important from the standpoint that the SDG may be able to determine if a peak dry density has been achieved in the field for a specific moisture condition, but it will be unable to determine if much relative change in density has occurred. In the sandier soils where the correlation appears linear, little range in dry density response is provided by the SDG, versus a large range in density from the nuclear gauge. In cases where a scattering of data points is apparent, there is less correlation but a better spread in range between the two devices.

No further statistically relevant internal data from the SDG were available to refine these trends. Therefore, as noted in Berney and Kyzar (2012), inputting the proper soil properties into the SDG along with a field dry density correction factor is seen as the best approach to minimize data scatter.

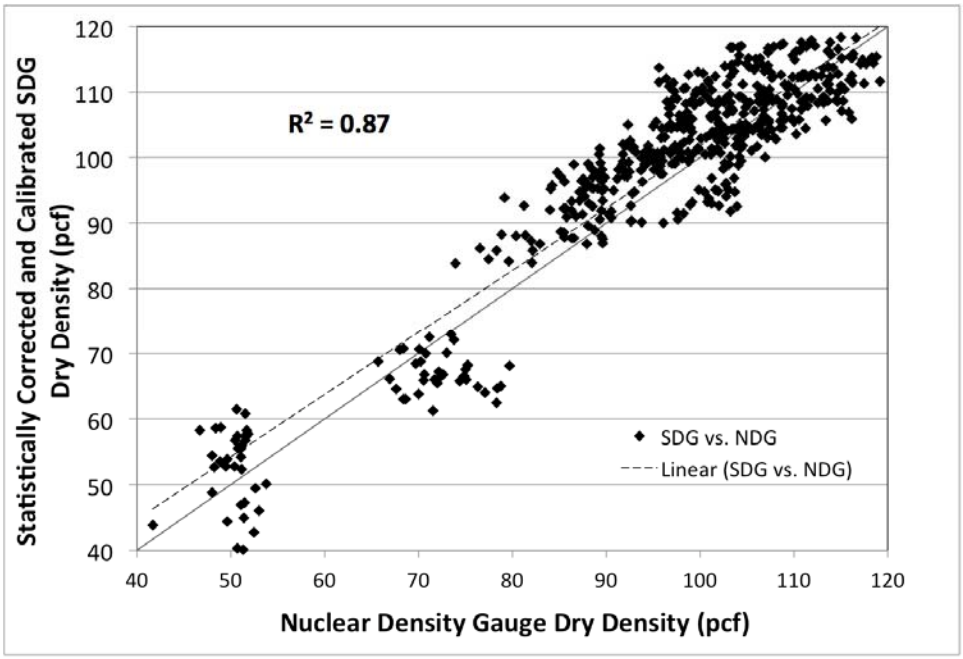

Figure 17. Comparison of NDG to SDG dry density with statistical correction and calibrated to one known density point in the test section.

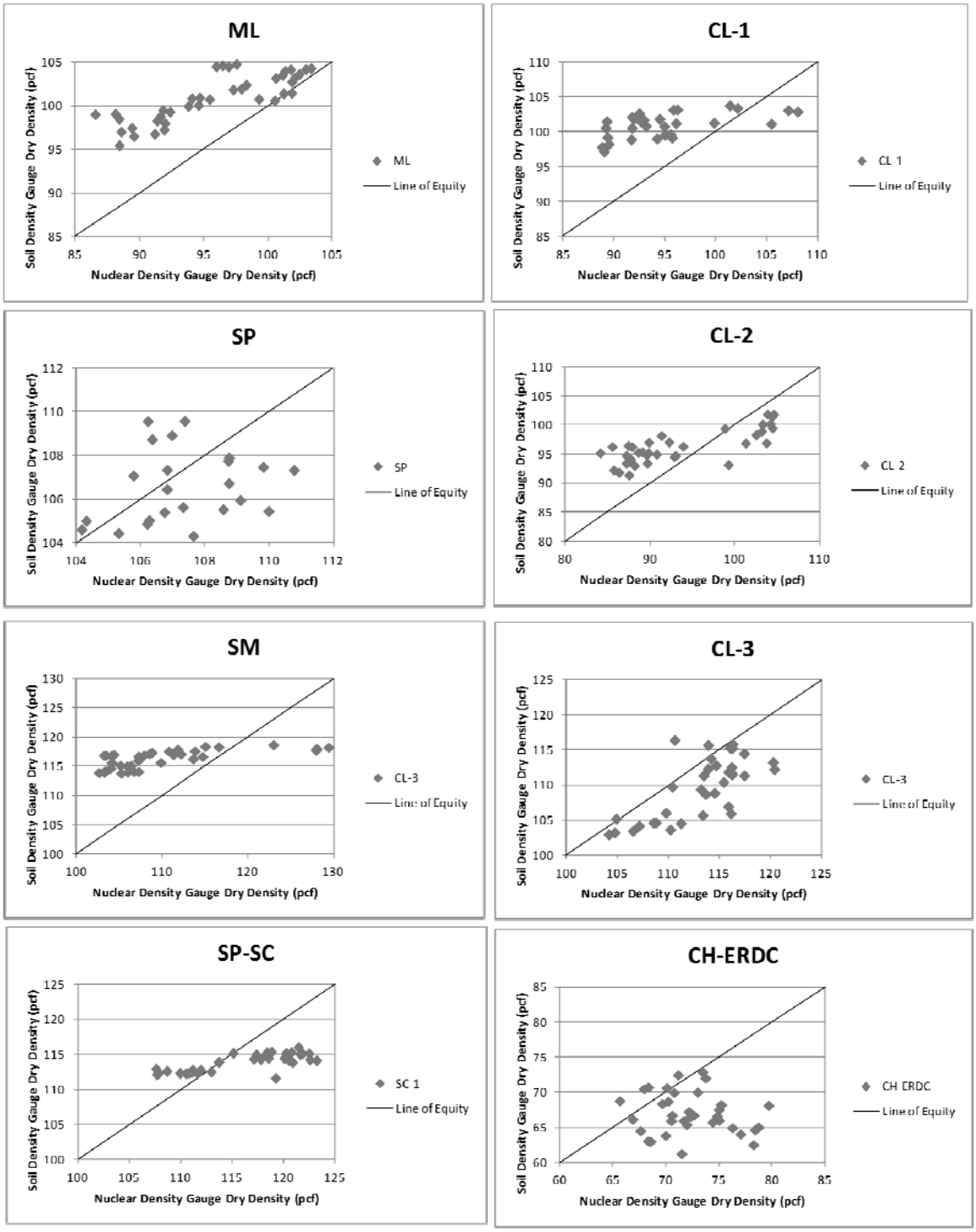

Figure 18. Individual NDG-corrected SDG dry density comparisons of selected soil classifications.

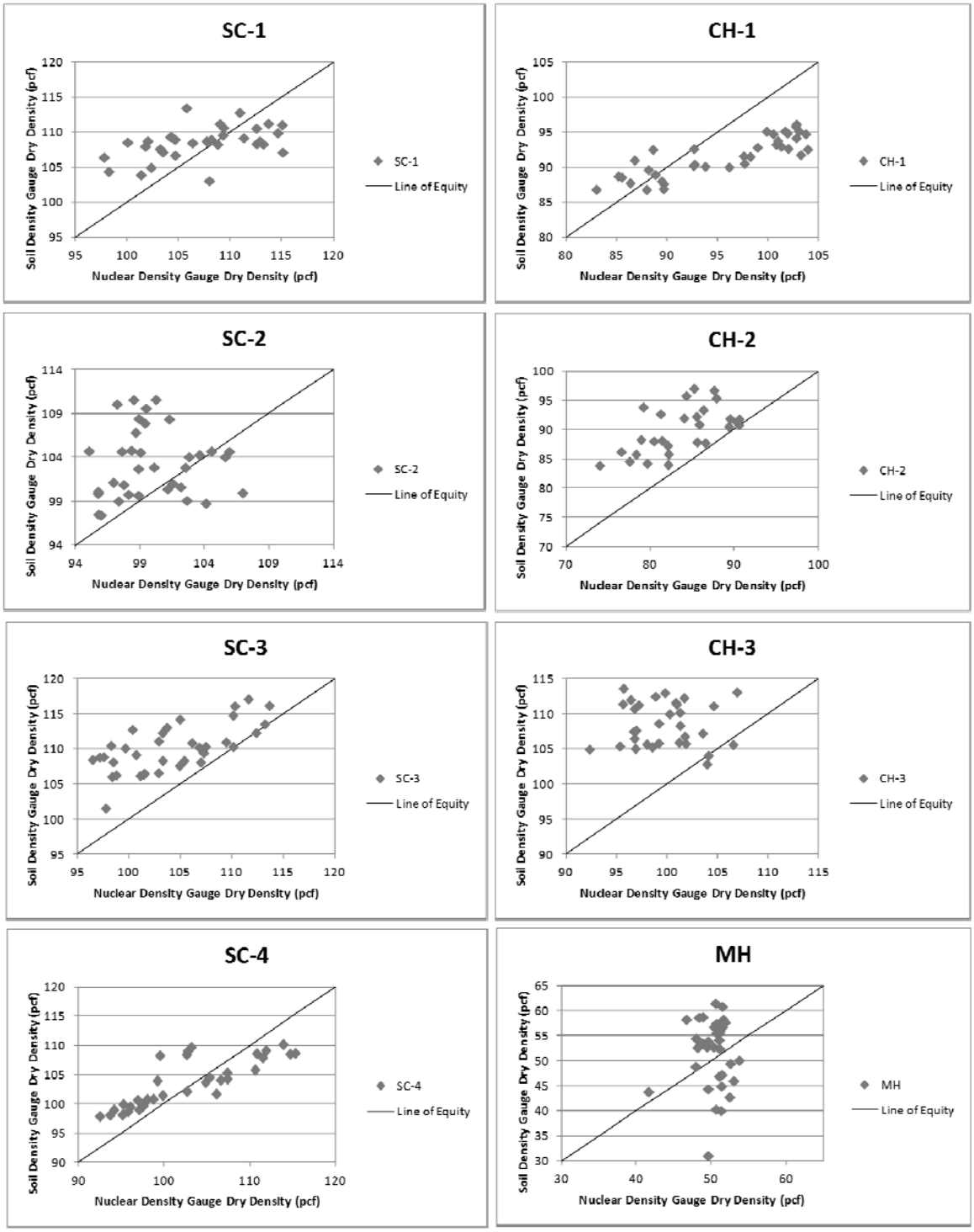

Figure 19. Additional individual NDG-corrected SDG dry density comparisons of selected soil classifications.

5 Conclusions and Recommendations

Conclusions

The following conclusions were derived from the evaluation of the SDG for monitoring soil density.

- When compared to the NDG, density data collected with the SDG in an uncalibrated state (Figure 15) contained sufficient scatter that no practical interpretation of the data could be made as it relates to the true field density. Therefore, calibration of the SDG is critical to its effective use.
- When compared to the NDG, density data collected with the SDG calibrated with known soil properties (Figure 16) was able to distinguish changes in density based on gross changes in field condition (i.e., clayey versus sandy soil), but experienced significant banding within a known soil type, interpreting all data collected on a given soil type as having the same magnitude of density. Therefore, the SDG is unable to distinguish between density changes occurring during the compaction process without the benefit of a known field density correction.
- When compared to the NDG, density data collected with the SDG calibrated with both known soil properties and a single density value from the NDG for each soil tested (Figure 17), better scaled the data to differentiate changes between both field conditions and compaction level. However, a reduced level of banding was still present within all fine-grained soils types (Figures 18 and 19), as the SDG struggled to distinguish small changes in field density occurring during compaction.

Recommendations

Based on the comparisons between the SDG and the NDG data, the following is recommended.

- Soil plasticity characteristics should be considered for refining the SDG's algorithms to calculate soil density.
- The SDG is only recommended for military contingency construction scenarios, as long as its dry density is calibrated to at least one independent density sample taken in the field with an alternative device such as the NDG.

- The SDG is not recommended as a Quality Control/Quality Assurance tool in critical or permanent infrastructure construction scenarios where more precise measurements of soil density are required.

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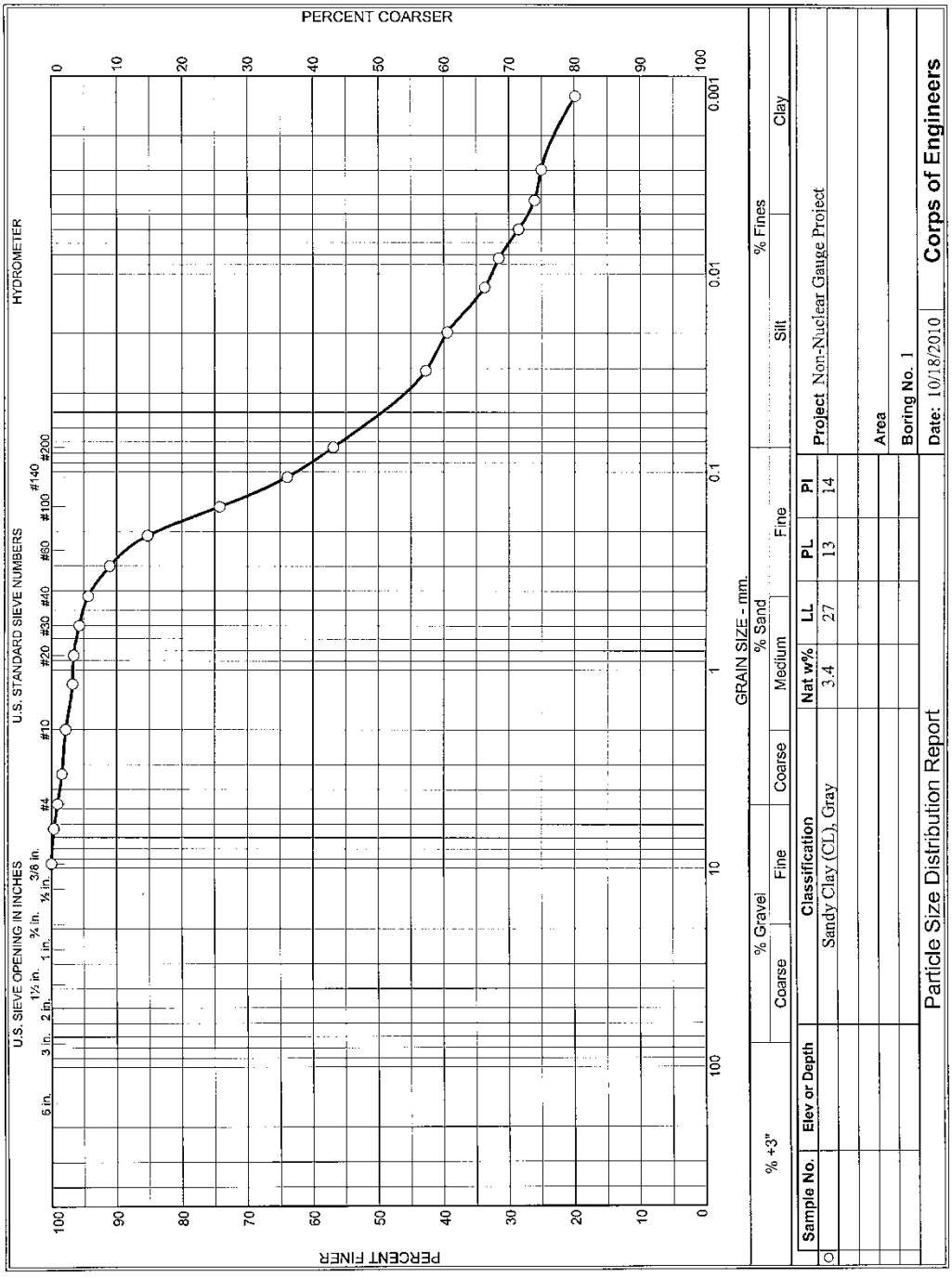
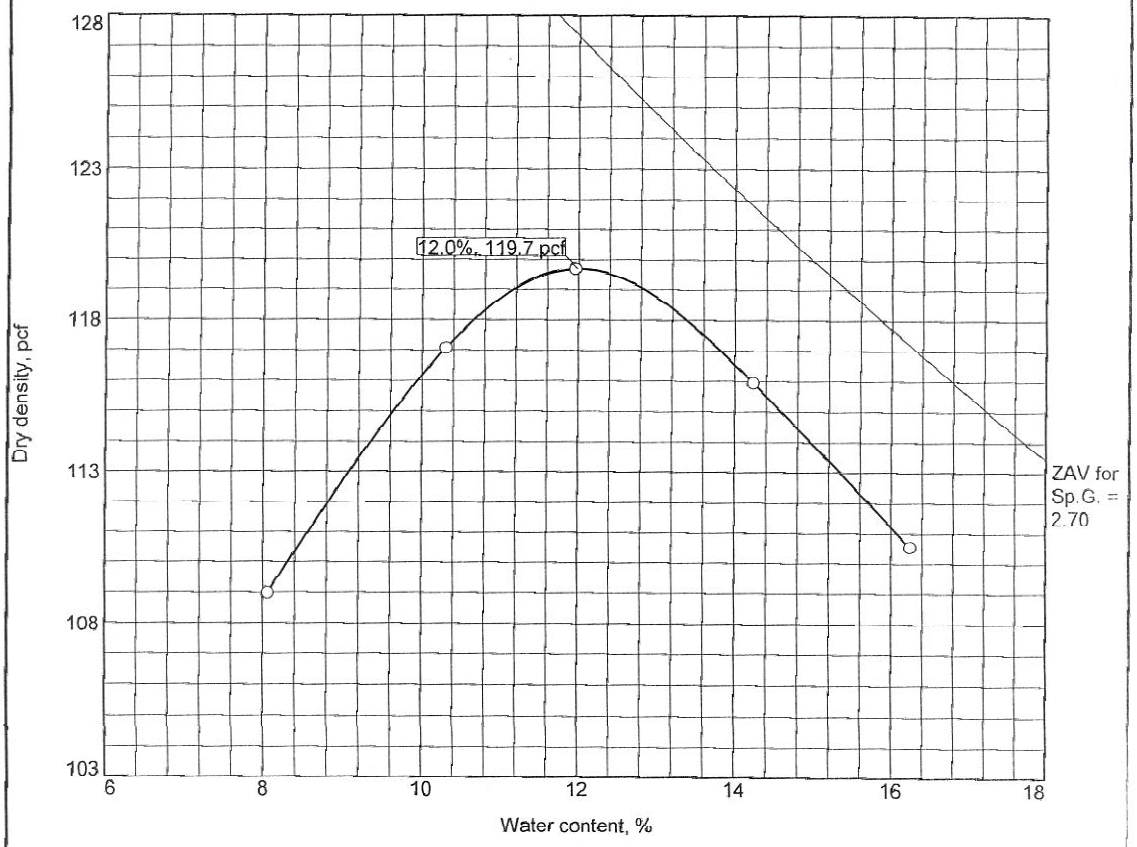
Appendix A: Soil Tests Data

CL-1



COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
			2.39	2.70 Est.	27	14		

TEST RESULTS

Maximum dry density = 119.7 pcf

Optimum moisture = 12.0 %

MATERIAL DESCRIPTION

Clay (CL), Gray

Project No. Md3510 **Client:** Mariely Mejias

Project: Non-Nuclear Gauge Project

o **Source of Sample:** Stock Pile #1

Remarks:

Esatemated Gravity 2.70, Compacted using CBR Molds.

Corps of Engineers
Engineer Research Development Center

Figure

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CL1			
Location:				
Sample No.:				
Flask No.:	12	16		
Weight dry soil after test, g, (M_s) :	84.49	85.19		
Test temp., °C:	19.5	19.5		
Average calibrated weight of flask, g, (M_p):	167.30	173.12		
Average calibrated volume of flask, ml, (Vp):	499.41	499.32		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	718.68	724.94		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99831	0.99831		
Temp. coefficient, (Table 1 (K)) :	1.00010	1.00010		
$M_{pw,t}$ =	665.86	671.59		
G_t =	2.67	2.68		
$G_{20°C}$ =	2.67	2.68		
Average $G_{20°C}$ =	2.67			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CL), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

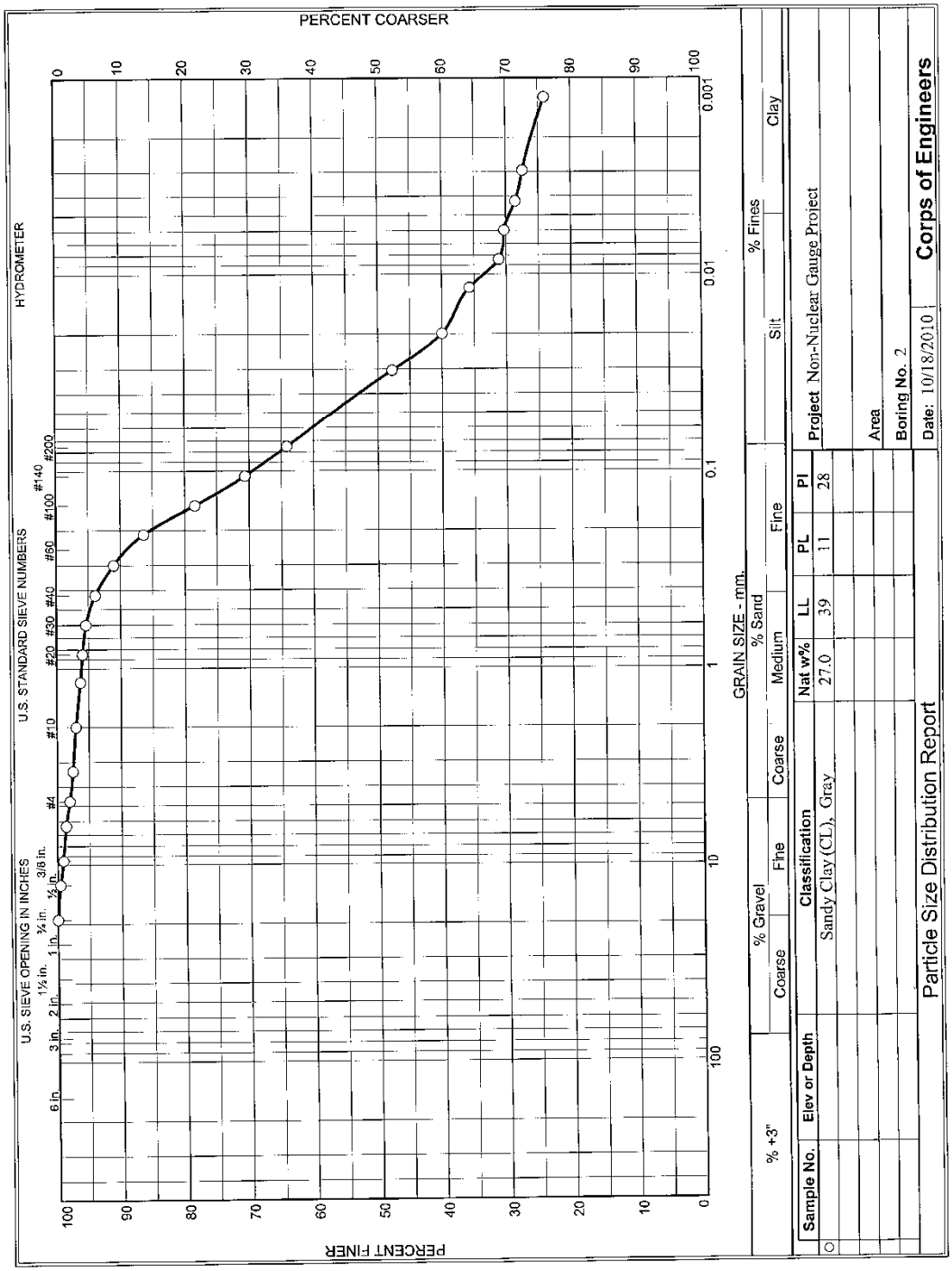
Description of soil or material excluded: _____

Remarks: _____

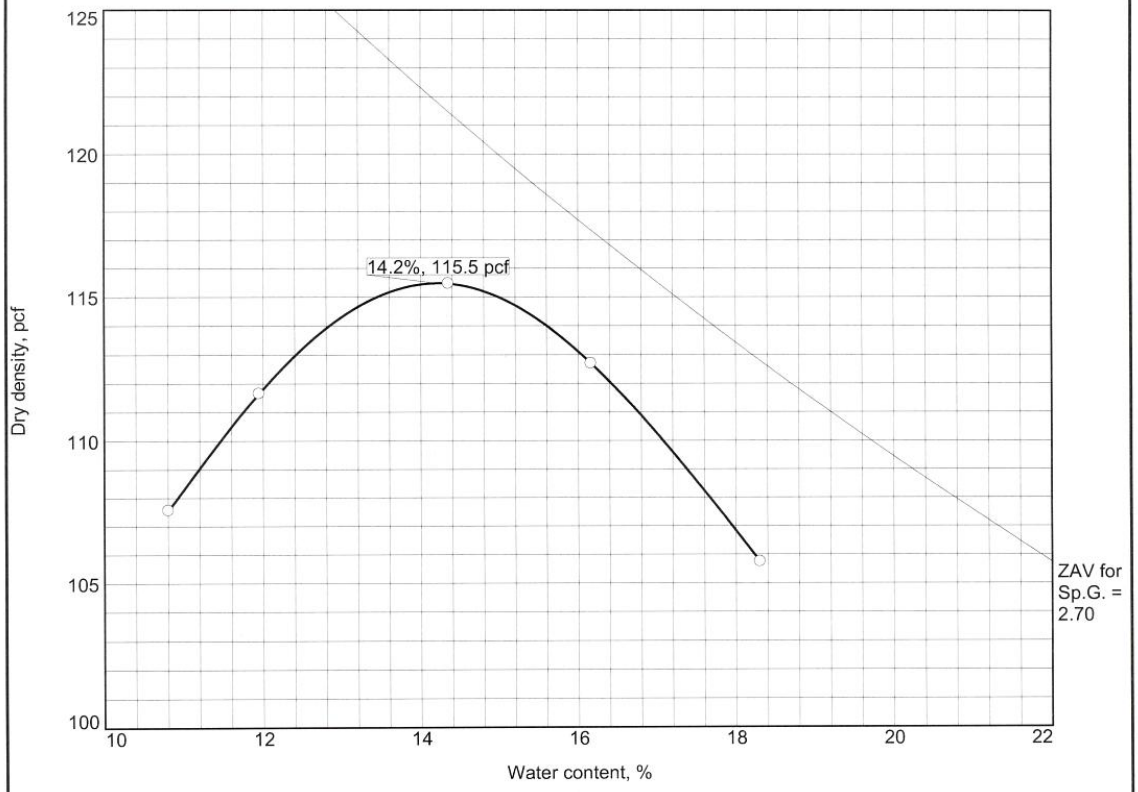
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

CL-2


PERCENT COARSER
PERCENT FINER
HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
6 in
3 in
2 in
1½ in
1 in
¾ in
½ in
3/8 in
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
% +3"
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Sandy Clay (CL), Gray
27.0
39
11
28
Project Non-Nuclear Gauge Project
Area
Boring No. 2
Date: 10/18/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 1557-00 Method C Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
			3.2	2.70 est.	39	28		

TEST RESULTS

Maximum dry density = 115.5 pcf

Optimum moisture = 14.2 %

MATERIAL DESCRIPTION

Clay (CL), Gray

Project No. Md3510 **Client:** Mariely Mejias

Project: Non-Nuclear Gauge Project

○ **Source of Sample:** Stock Pile #2

Remarks:

Estimated specific gravity 2.70, Compacted using CBR Molds.

Corps of Engineers
Engineer Research Development Center

Figure

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CL2			
Location:				
Sample No.:				
Flask No.:	20	25		
Weight dry soil after test, g, (M_s) :	76.18	72.56		
Test temp., °C:	19.5	19.4		
Average calibrated weight of flask, g, (M_p):	171.39	168.90		
Average calibrated volume of flask, ml, (Vp):	499.32	499.31		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	718.00	713.20		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.998331	0.998333		
Temp. coefficient, (Table 1 (K)) :	1.000101	1.000112		
$M_{pw,t}$ =	669.85	667.37		
G_t =	2.72	2.71		
$G_{20°C}$ =	2.72	2.71		
Average $G_{20°C}$ =	2.72			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CL), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

Description of soil or material excluded: _____

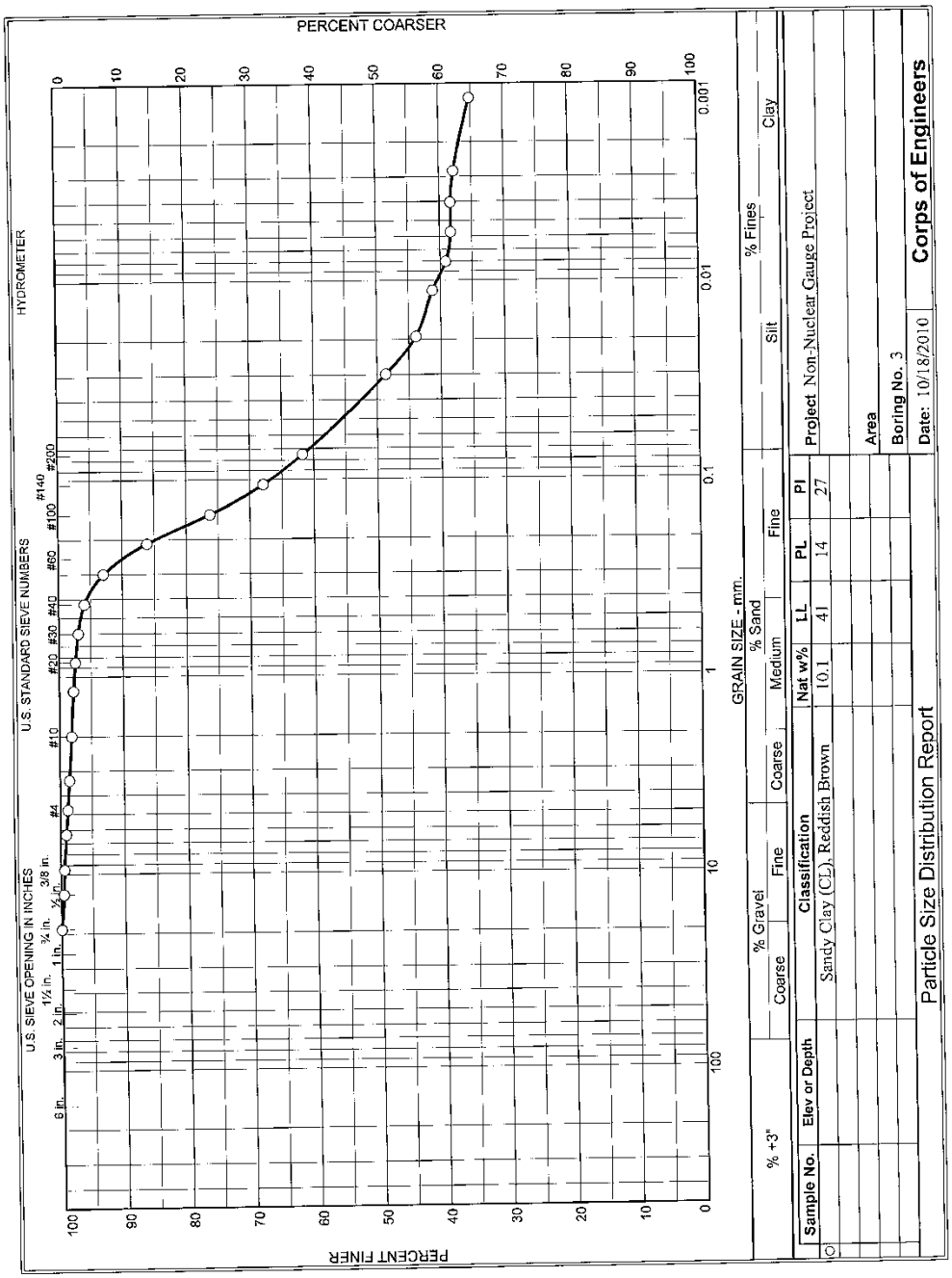
Remarks: _____

Technician: AT Computed by: AT Checked by: LRC

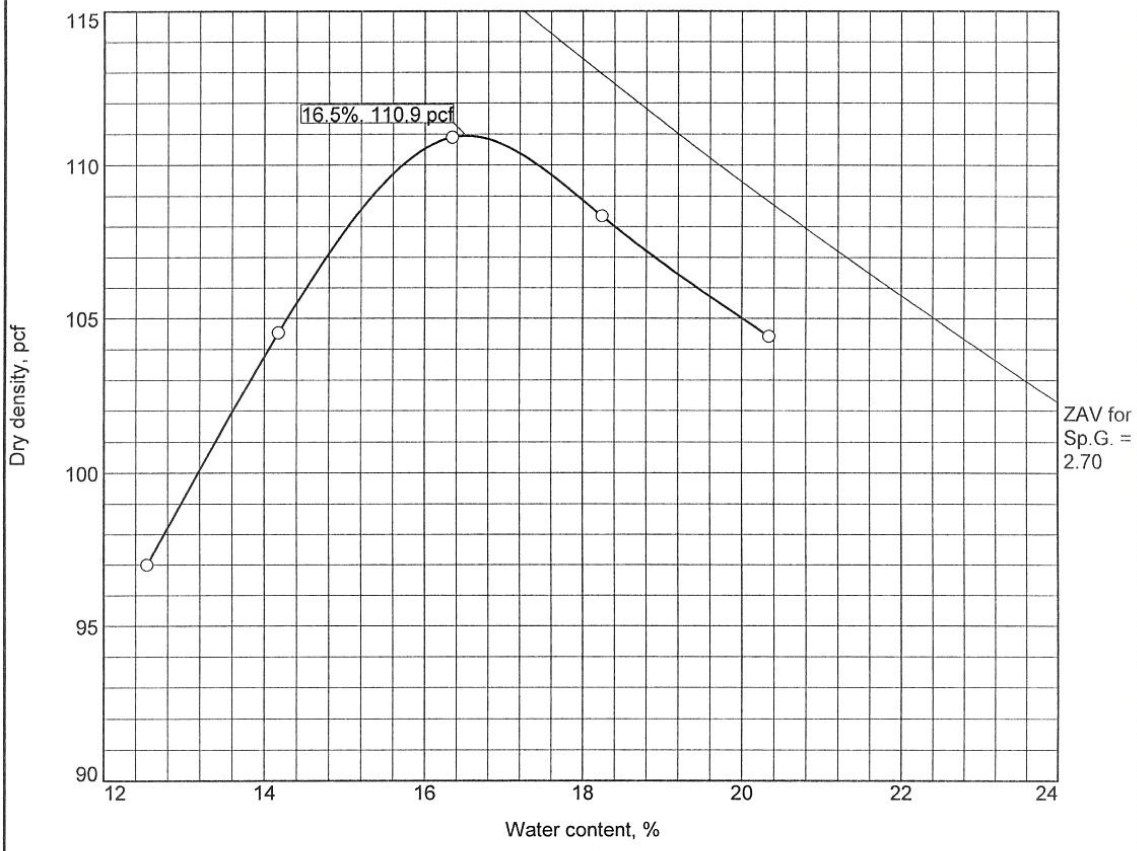
Revised 8/8/11

CH-1

(Note: This soil was classified as CL by the MTC and as CH by the University of Houston)



COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method B Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
			2.3	2.70 est.	41	27		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 110.9 pcf Optimum moisture = 16.5 %	Clay (CL), Reddish Brown

Project No. Md3510 **Client:** Mariely Mejias
Project: Non-Nuclear Gauge Project

○ **Source of Sample:** Stock Pile #3

Remarks:
Estimated gravity

Corps of Engineers
Engineer Research Development Center

Figure

Tested By: CEC **Checked By:** RC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CH1			
Location:				
Sample No.:				
Flask No.:	37	40		
Weight dry soil after test, g, (M_s) :	77.96	80.75		
Test temp., °C:	19.4	19.4		
Average calibrated weight of flask, g, (M_p):	177.20	174.27		
Average calibrated volume of flask, ml, (Vp):	499.34	499.44		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	725.00	723.94		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99833	0.99833		
Temp. coefficient, (Table 1 (K)) :	1.00012	1.00012		
$M_{pw,t}$ =	675.70	672.87		
G_t =	2.72	2.72		
$G_{20°C}$ =	2.72	2.72		
Average $G_{20°C}$ =	2.72			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CH), Reddish Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

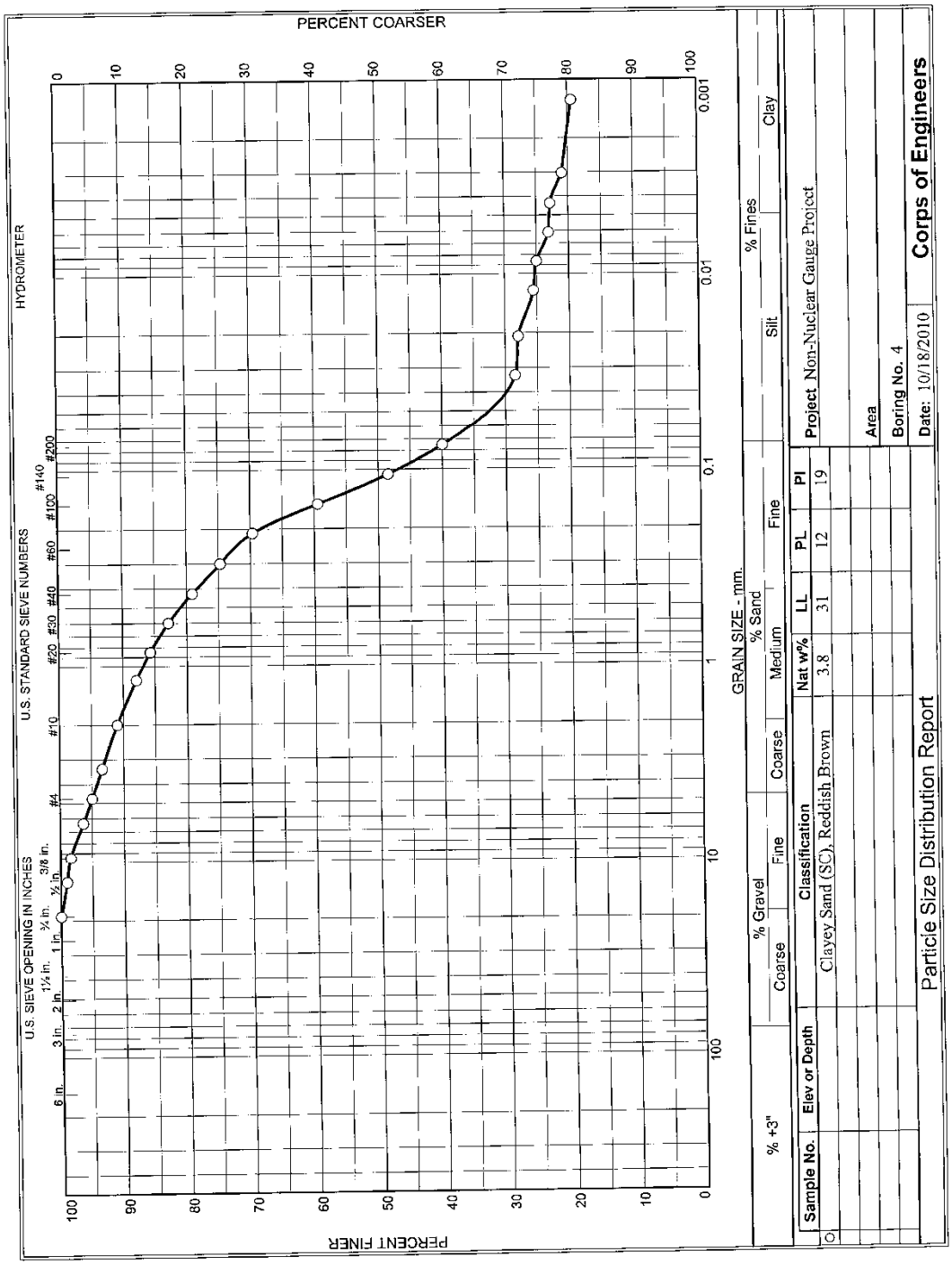
Description of soil or material excluded: _____

Remarks: _____

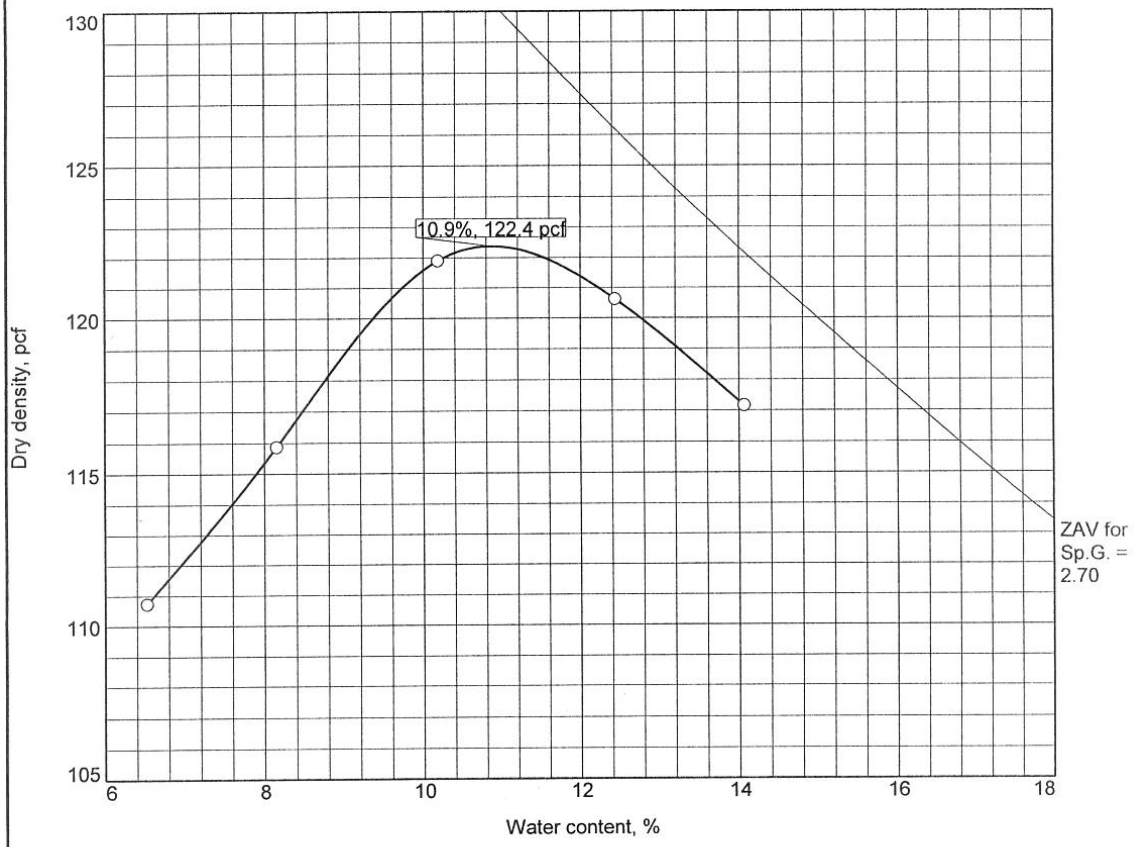
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SC-1


PERCENT COARSER
PERCENT FINER
HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
% +3"
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clayey Sand (SC), Reddish Brown
3.8
31
12
19
Project Non-Nuclear Gauge Project
Area
Boring No. 4
Date: 10/18/2010
Corps of Engineers
Particle Size Distribution Report
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
			2.2	2.70 est.	31	19		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 122.4 pcf Optimum moisture = 10.9 %	Clay (CL), Reddish Brown
Project No. Md3510 **Client:** Mariely Mejias **Project:** Non-Nuclear Gauge Project ○ **Source of Sample:** Stock Pile #4	**Remarks:** Estamated Gravity
Corps of Engineers **Engineer Research Development Center**	Figure

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 04/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SC1			
Location:				
Sample No.:				
Flask No.:	20	24		
Weight dry soil after test, g, (M_s) :	87.24	90.86		
Test temp., °C:	20.4	20.4		
Average calibrated weight of flask, g, (M_p):	176.62	174.24		
Average calibrated volume of flask, ml, (Vp):	499.46	499.37		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	730.17	729.98		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.998612	0.998612		
Temp. coefficient, (Table 1 (K)) :	0.999927	0.999927		
$M_{pw,t}$ =	675.14	672.67		
G_t =	2.71	2.71		
$G_{20°C}$ =	2.71	2.71		
Average $G_{20°C}$ =	2.71			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clayey Sand (SC), Reddish Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

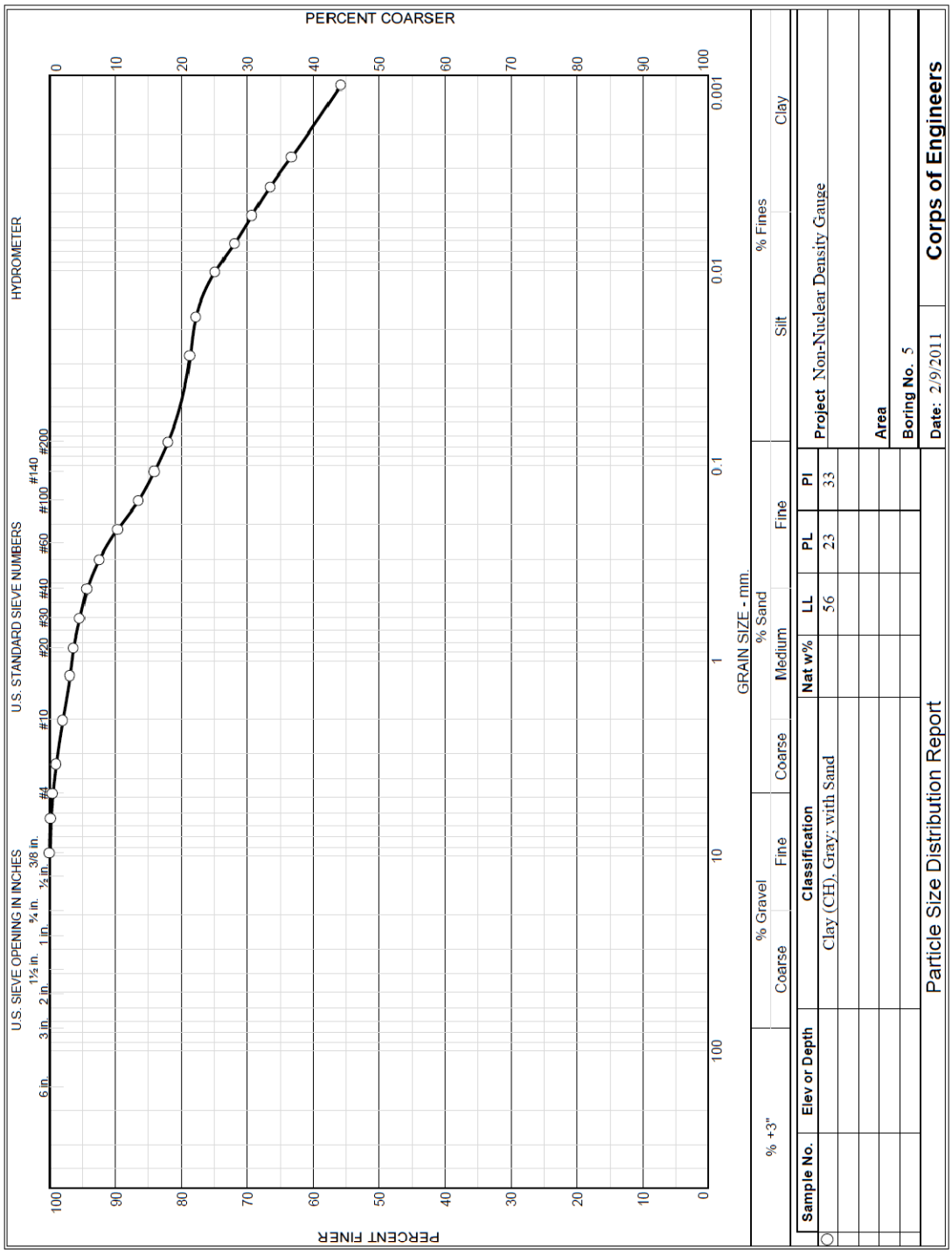
Description of soil or material excluded: _____

Remarks: _____

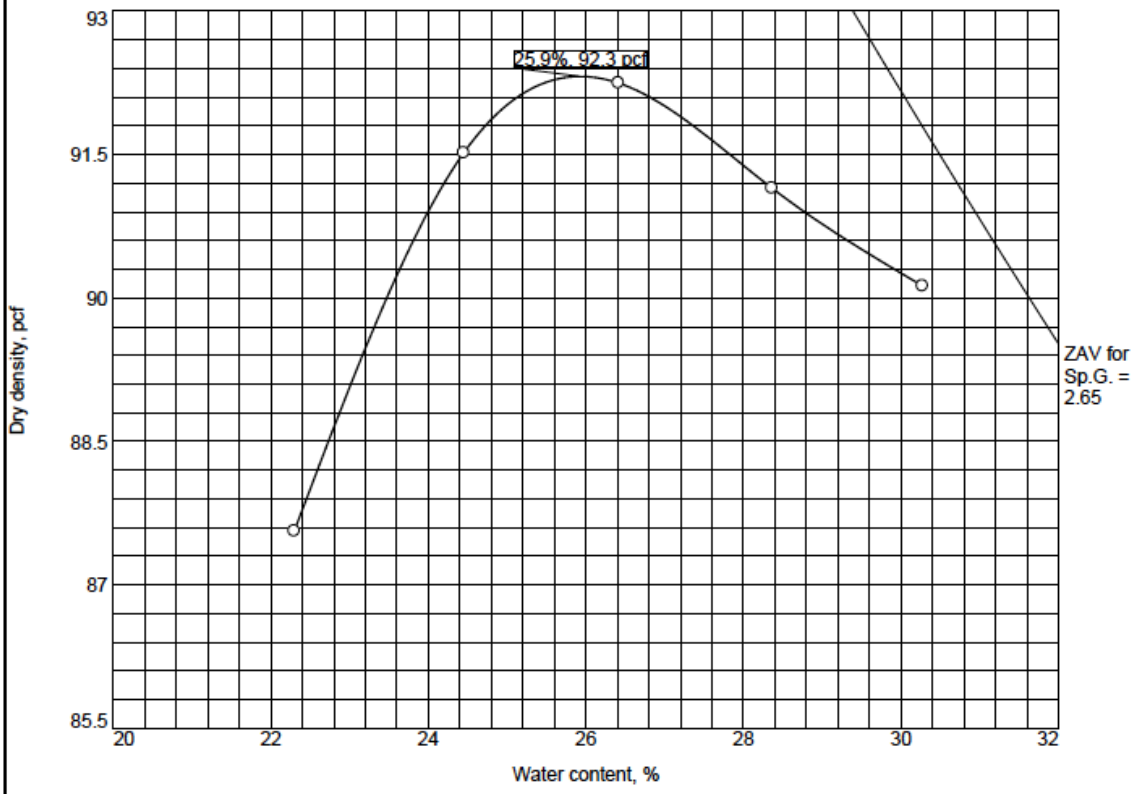
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

CH-2


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE - mm.
% Gravel
% Sand
% Fines
Coarse
Fine
Coarse
Medium
Fine
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clay (CH). Gray; with Sand
56
23
33
Project Non-Nuclear Density Gauge
Area
Boring No. 5
Date: 2/9/2011
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
			6.4%	2.65	56	33		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 92.3 pcf Optimum moisture = 25.9 %	Clay (CH), Gray
Project No. MD0511 **Client:** Marley Majiras **Project:** Non-Nuclear Density Gauge ○ **Source of Sample:** Stock Pile #5 **Sample Number:** 5	**Remarks:** Estimated Gravity 2.65
Corps of Engineers **Engineer Research Development Center**	**Figure**

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CH2			
Location:				
Sample No.:				
Flask No.:	44	48		
Weight dry soil after test, g, (M_s) :	84.21	73.31		
Test temp., °C:	19.4	19.4		
Average calibrated weight of flask, g, (M_p):	168.89	174.58		
Average calibrated volume of flask, ml, (Vp):	499.34	499.32		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	721.02	719.89		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99833	0.99833		
Temp. coefficient, (Table 1 (K)) :	1.00012	1.00012		
$M_{pw,t}$ =	667.36	673.07		
G_t =	2.75	2.77		
$G_{20°C}$ =	2.76	2.77		
Average $G_{20°C}$ =	**2.76**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CH), Gray

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

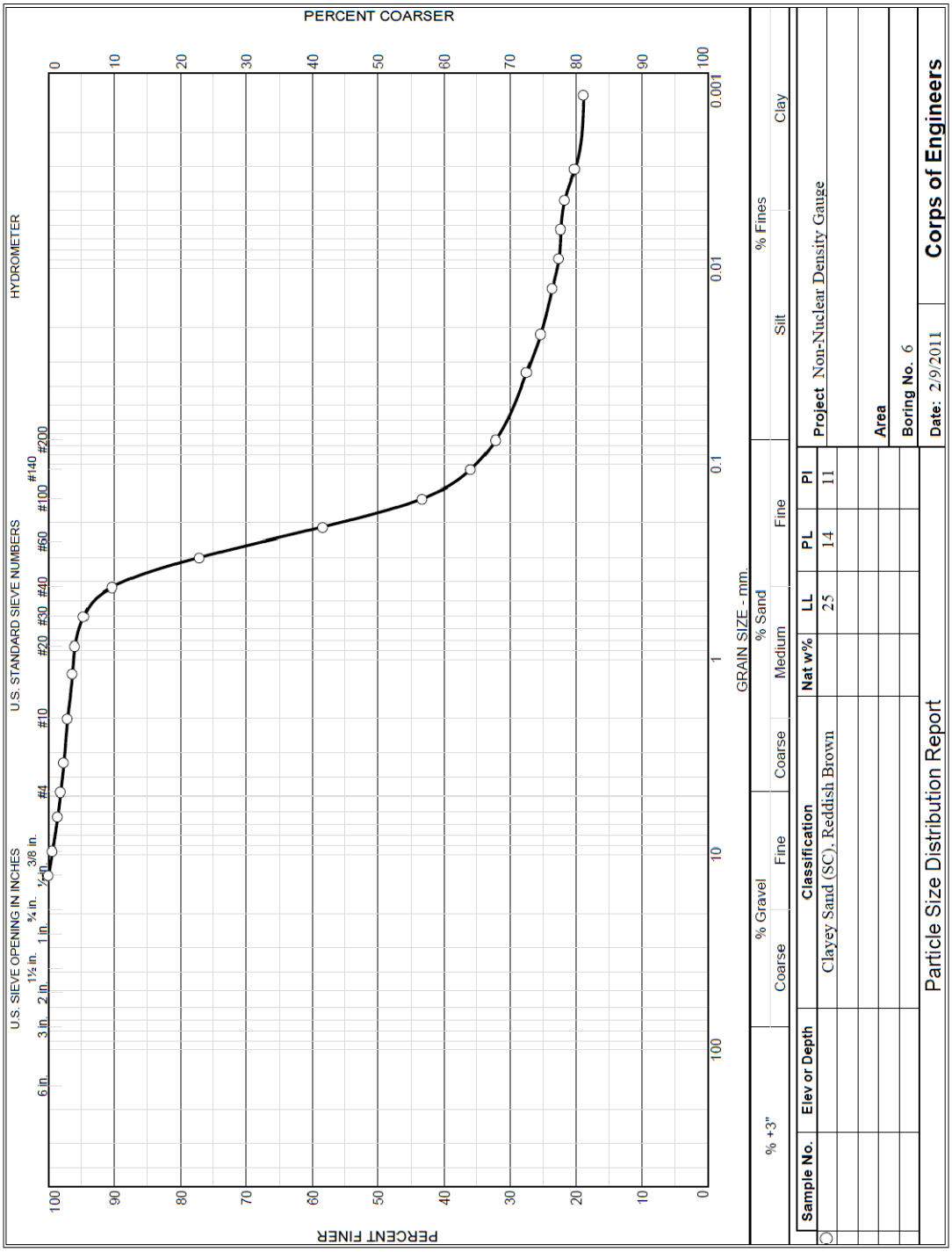
Description of soil or material excluded: _____

Remarks: _____

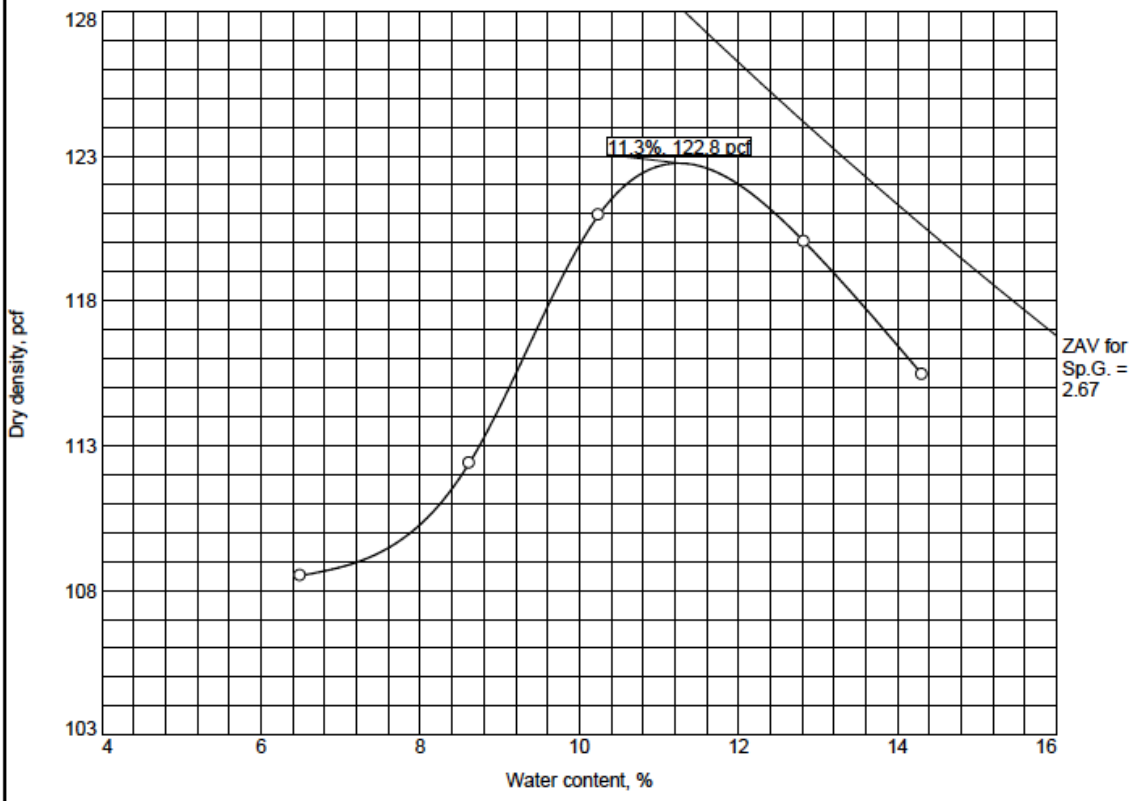
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SC-2


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clayey Sand (SC), Reddish Brown
25
14
11
Project Non-Nuclear Density Gauge
Area
Boring No. 6
Date: 2/9/2011
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	CL		2.1	2.67	25	11		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 122.8 pcf Optimum moisture = 11.3 %	Clay (CL), Reddish Brown
Project No. MD0511 **Client:** Marley Majiras **Project:** Non-Nuclear Density Gauge ○ **Source of Sample:** Stock Pile #6 **Sample Number:** 6 **Corps of Engineers** **Engineer Research Development Center**	**Remarks:** Estimated Gravity 2.67 **Figure**

Tested By: CEC\LDD **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 04/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SC2			
Location:				
Sample No.:				
Flask No.:	28	35		
Weight dry soil after test, g, (M_s) :	80.08	76.35		
Test temp., °C:	20.4	20.0		
Average calibrated weight of flask, g, (M_p):	180.07	168.28		
Average calibrated volume of flask, ml, (Vp):	499.42	499.48		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	728.90	714.75		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99812	0.99820		
Temp. coefficient, (Table 1 (K)) :	0.99992	0.99999		
$M_{pw,t}$ =	679.55	666.86		
G_t =	2.69	2.68		
G_{20^oC} =	2.69	2.68		
Average G_{20^oC} =	2.69			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clayey Sand (SC), Reddish Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

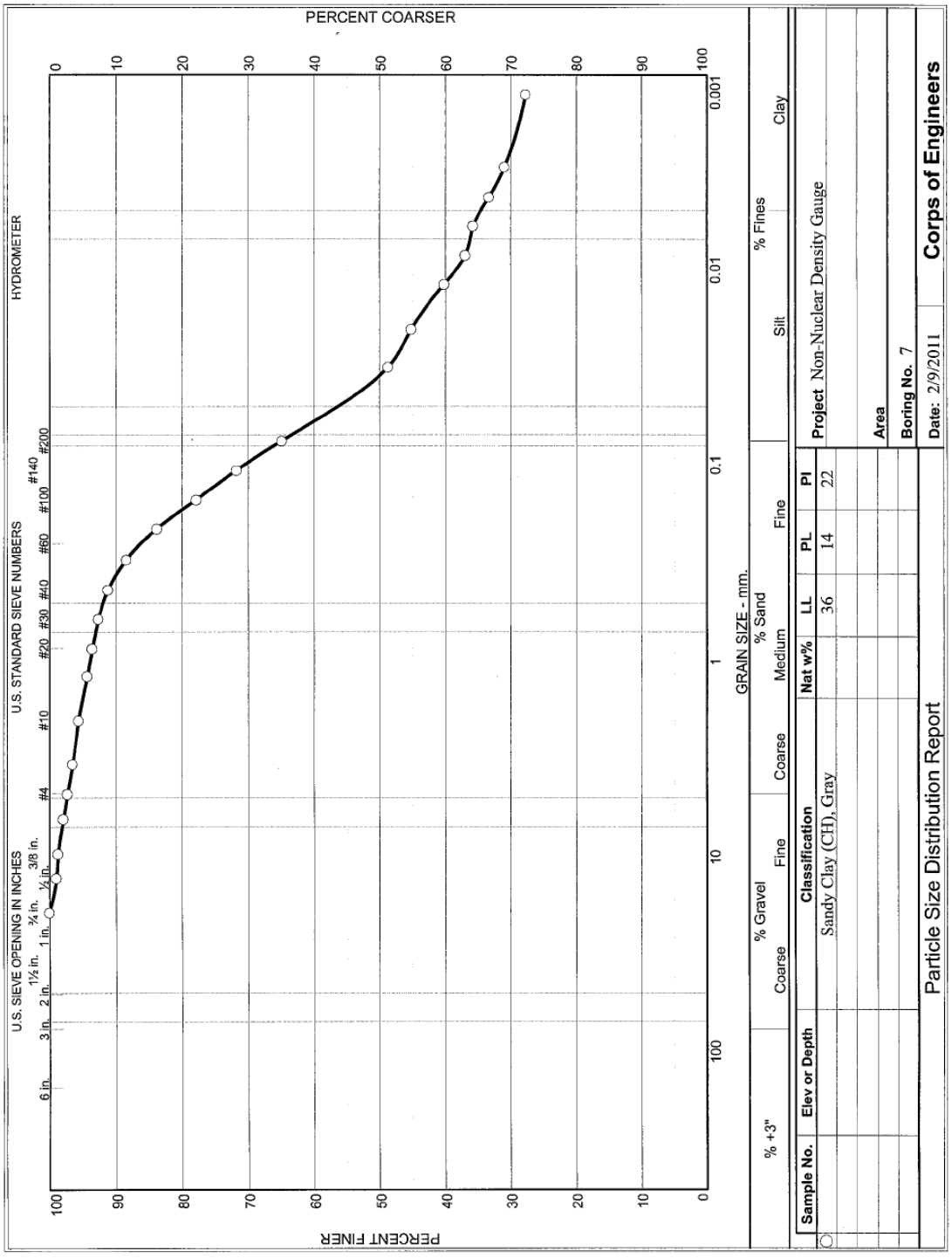
Description of soil or material excluded: _____

Remarks: _____

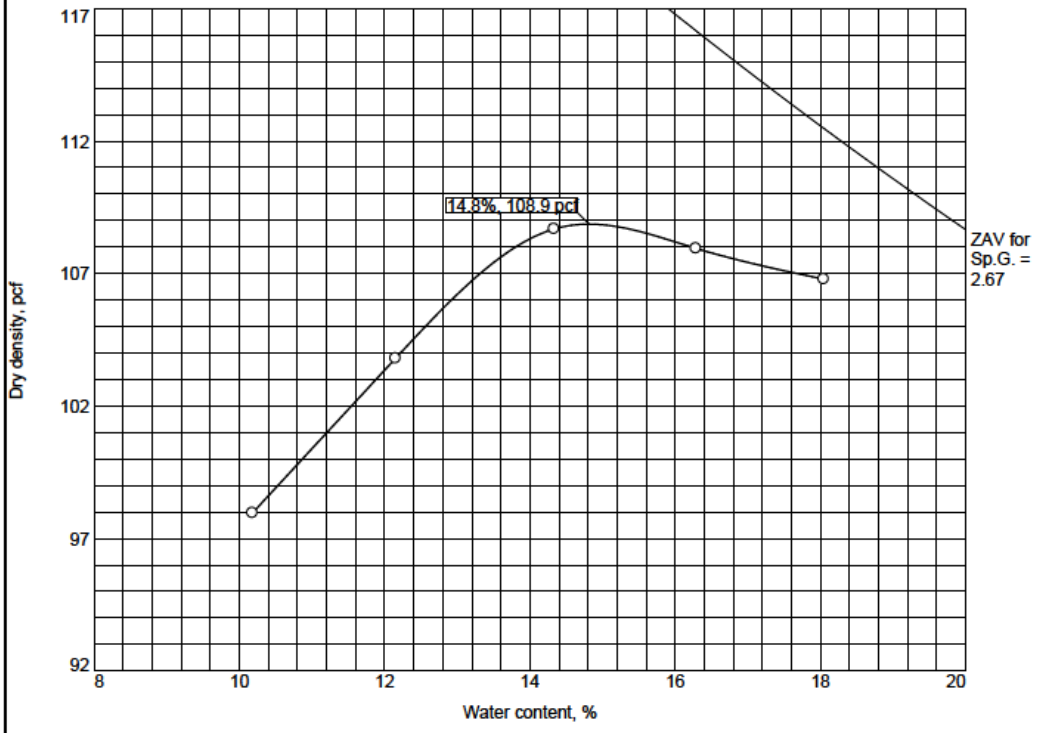
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

CH-3


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Sandy Clay (CH), Gray
36
14
22
Project Non-Nuclear Density Gauge
Area
Boring No. 7
Date: 2/9/2011
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
	CL		3.3	2.67 est.	36	22		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 108.9 pcf Optimum moisture = 14.8 %	Clay (CL), Gray

Project No. MD0511 **Client:** Marley Majiras
Project: Non-Nuclear Density Gauge

○ **Source of Sample:** Stock Pile #7 **Sample Number:** 7

Remarks:
Estimated Gravity 2.67

Corps of Engineers
Engineer Research Development Center

Figure

Tested By: CEC\LDD **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CH3			
Location:				
Sample No.:				
Flask No.:	53	56		
Weight dry soil after test, g, (M_s) :	85.54	87.44		
Test temp., °C:	19.4	19.4		
Average calibrated weight of flask, g, (M_p):	168.37	171.52		
Average calibrated volume of flask, ml, (Vp):	499.45	499.43		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	720.98	725.25		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99833	0.99833		
Temp. coefficient, (Table 1 (K)) :	1.00012	1.00012		
$M_{pw,t}$ =	666.98	670.11		
G_t =	2.71	2.71		
$G_{20°C}$ =	2.71	2.71		
Average $G_{20°C}$ =	2.71			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CH), Gray

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

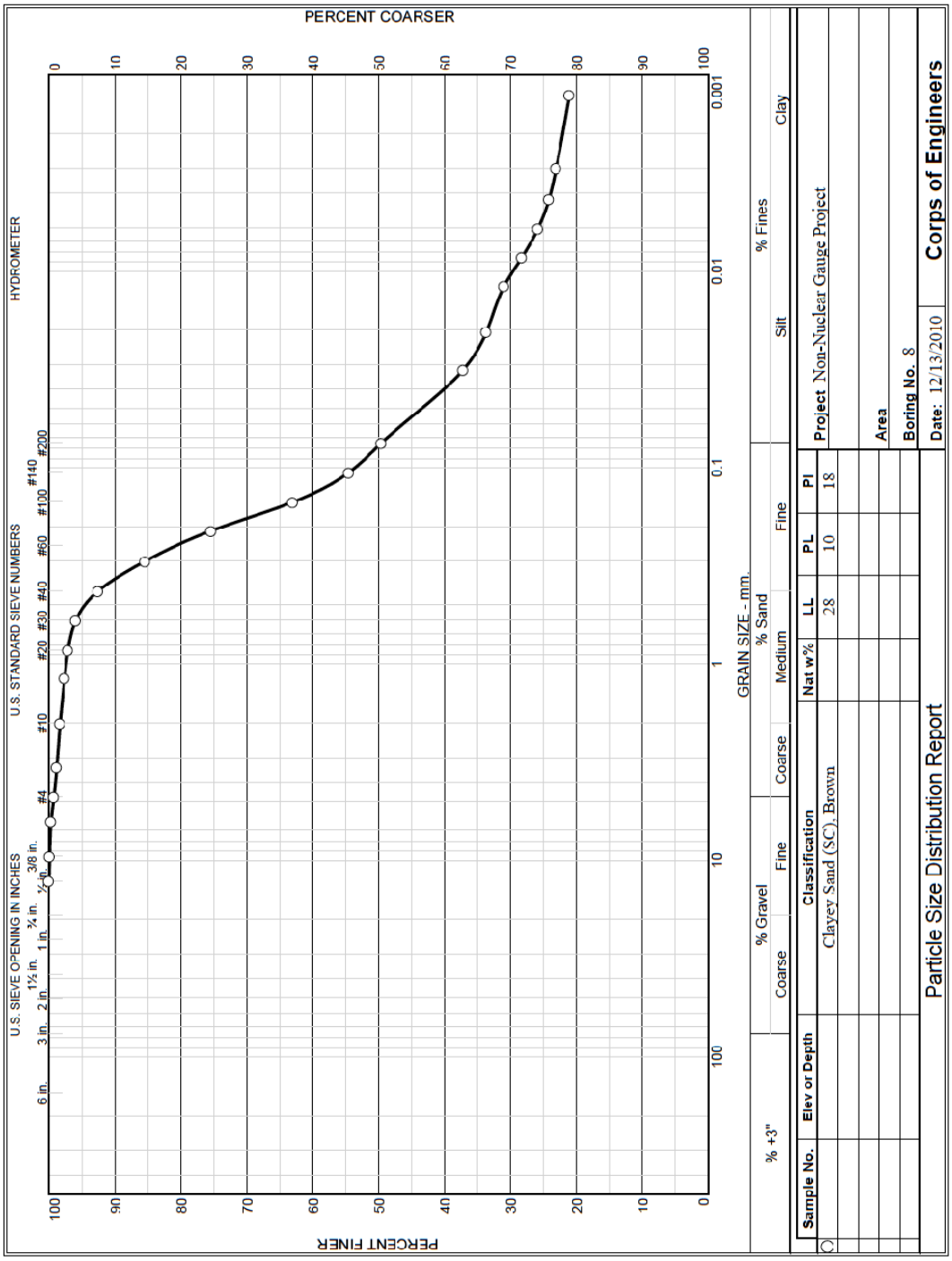
Description of soil or material excluded: _____

Remarks: _____

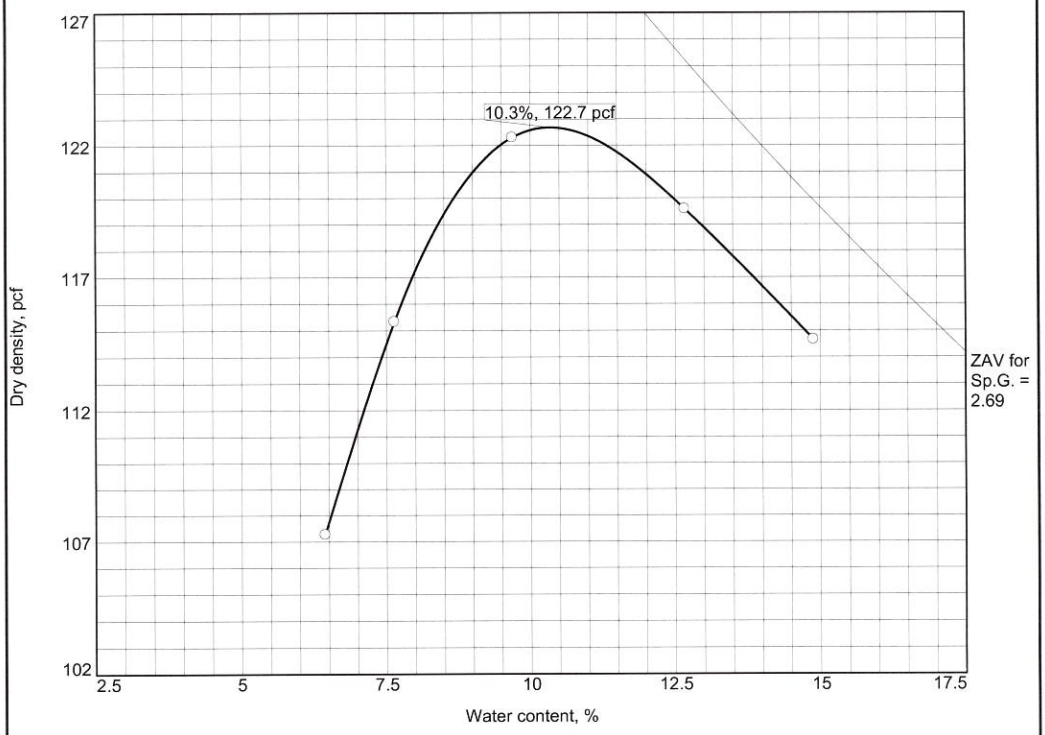
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SC-3


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clayey Sand (SC), Brown
28
10
18
Project Non-Nuclear Gauge Project
Area
Boring No. 8
Date: 12/13/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
			2.6	2.69 est.	28	18		

TEST RESULTS

Maximum dry density = 122.7 pcf

Optimum moisture = 10.3 %

MATERIAL DESCRIPTION

Clay (CL), Brown

Project No. Md3510 **Client:** Mariely Mejias

Project: Non-Nuclear Gauge Project

○ **Source of Sample:** Stock Pile #8

Remarks:

Estimated specific gravity 2.69, Compacted using CBR Molds.

Corps of Engineers
Engineer Research Development Center

Figure

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 04/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SC3			
Location:				
Sample No.:				
Flask No.:	36	40		
Weight dry soil after test, g, (M_s) :	81.83	77.40		
Test temp., °C:	20.5	20.2		
Average calibrated weight of flask, g, (M_p):	174.96	175.82		
Average calibrated volume of flask, ml, (Vp):	499.35	499.33		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	724.86	722.96		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99810	0.99816		
Temp. coefficient, (Table 1 (K)) :	0.99968	0.99996		
$M_{pw,t}$ =	673.96	674.23		
G_t =	2.70	2.70		
$G_{20°C}$ =	2.70	2.70		
Average $G_{20°C}$ =	2.70			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clayey Sand (SC), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

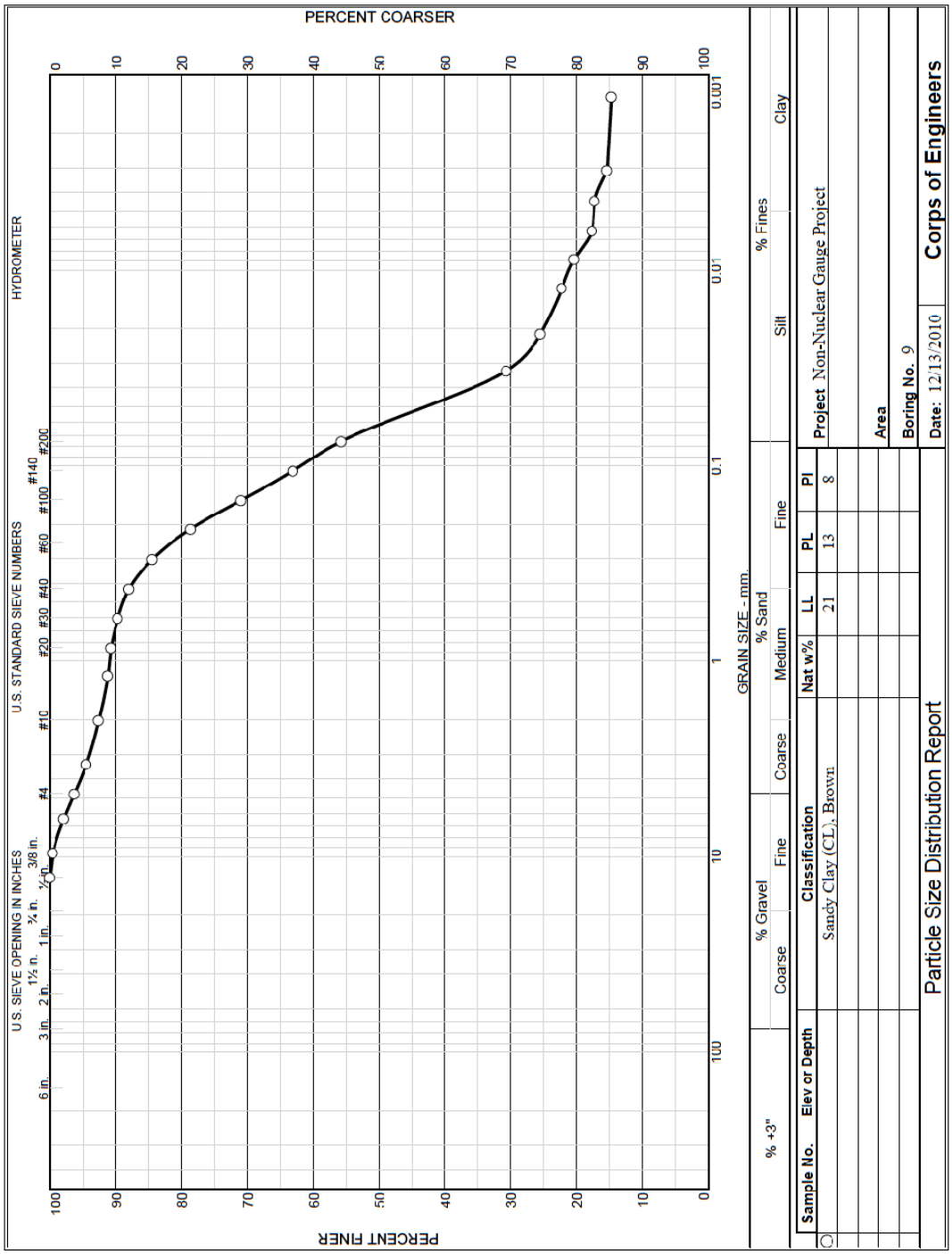
Description of soil or material excluded: _____

Remarks: _____

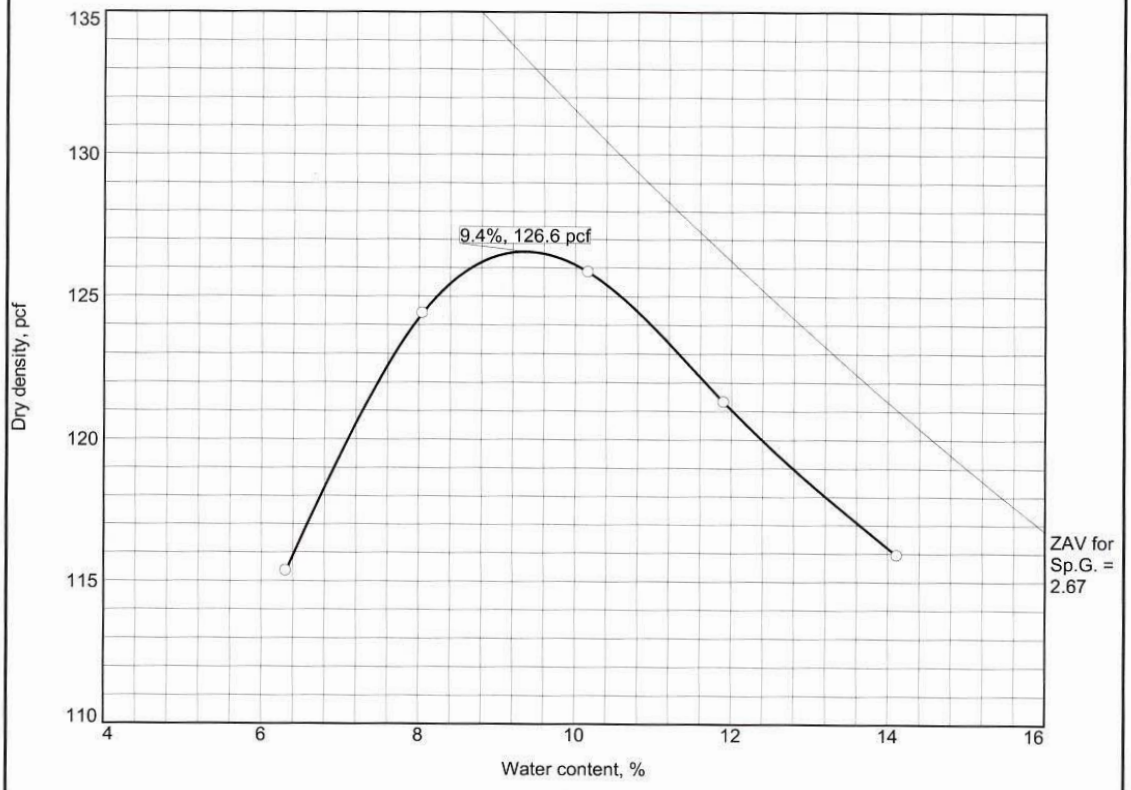
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

CL-3


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Sandy Clay (CL), Brown
21
13
8
Project Non-Nuclear Gauge Project
Area
Boring No. 9
Date: 12/13/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
			1.7	2.67 est.	21	8		

TEST RESULTS

Maximum dry density = 126.6 pcf

Optimum moisture = 9.4 %

Project No. Md3510 **Client:** Mariely Mejias

Project: Non-Nuclear Gauge Project

○ **Source of Sample:** Stock Pile #9

Corps of Engineers
Engineer Research Development Center

MATERIAL DESCRIPTION

Clay (CL), Brown

Remarks:

Estimated specific gravity 2.67, Compacted using CBR Molds.

Figure

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CL3			
Location:				
Sample No.:				
Flask No.:	28	32		
Weight dry soil after test, g, (M_s) :	93.71	92.86		
Test temp., °C:	19.4	19.4		
Average calibrated weight of flask, g, (M_p):	169.33	169.90		
Average calibrated volume of flask, ml, (Vp):	499.39	499.42		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	727.00	726.91		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99833	0.99833		
Temp. coefficient, (Table 1 (K)) :	1.00012	1.00012		
$M_{pw,t}$ =	667.86	668.48		
G_t =	2.71	2.70		
$G_{20°C}$ =	2.71	2.70		
Average $G_{20°C}$ =	**2.70**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CL), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

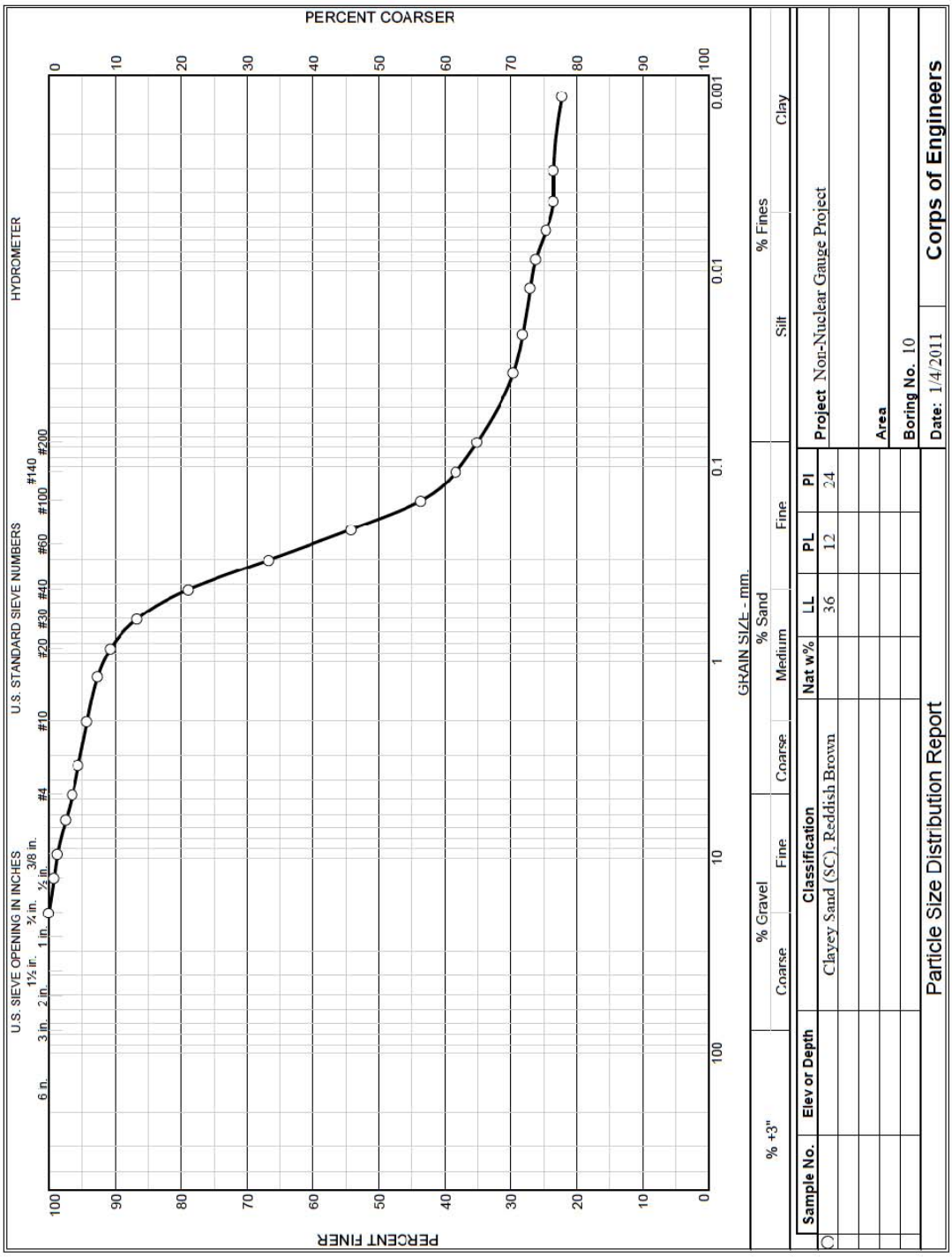
Description of soil or material excluded: _____

Remarks: _____

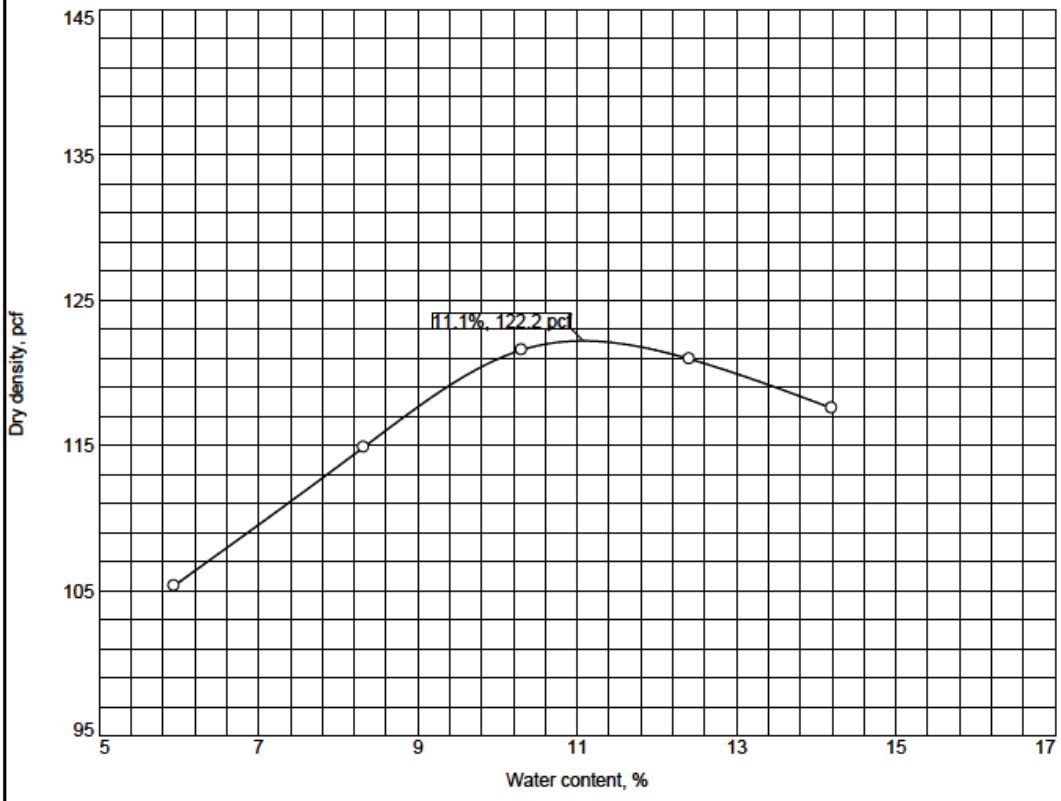
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SC-4


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clayey Sand (SC), Reddish Brown
36
12
24
Project Non-Nuclear Gauge Project
Area
Boring No. 10
Date: 1/4/2011
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method C Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
			2.4		36	24		

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 122.2 pcf Optimum moisture = 11.1 %	Clay (CL), Reddish Brown
Project No. Md3510 **Client:** Mariely Mejias **Project:** Non-Nuclear Gauge Project ○ **Source of Sample:** Stock Pile #10	**Remarks:** Estimated specific gravity 2.70, Compacted using CBR Molds.
Corps of Engineers **Engineer Research Development Center**	**Figure**

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 04/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SC4			
Location:				
Sample No.:				
Flask No.:	44	49		
Weight dry soil after test, g, (M_s) :	88.64	93.93		
Test temp., °C:	20.4	20.3		
Average calibrated weight of flask, g, (M_p):	178.85	179.27		
Average calibrated volume of flask, ml, (Vp):	499.31	499.37		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	733.06	736.84		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99812	0.99814		
Temp. coefficient, (Table 1 (K)) :	0.99992	0.99994		
$M_{pw,t}$ =	671.22	677.71		
G_t =	2.70	2.70		
$G_{20°C}$ =	2.70	2.70		
Average $G_{20°C}$ =	2.70			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clayey Sand (SC), Reddish Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

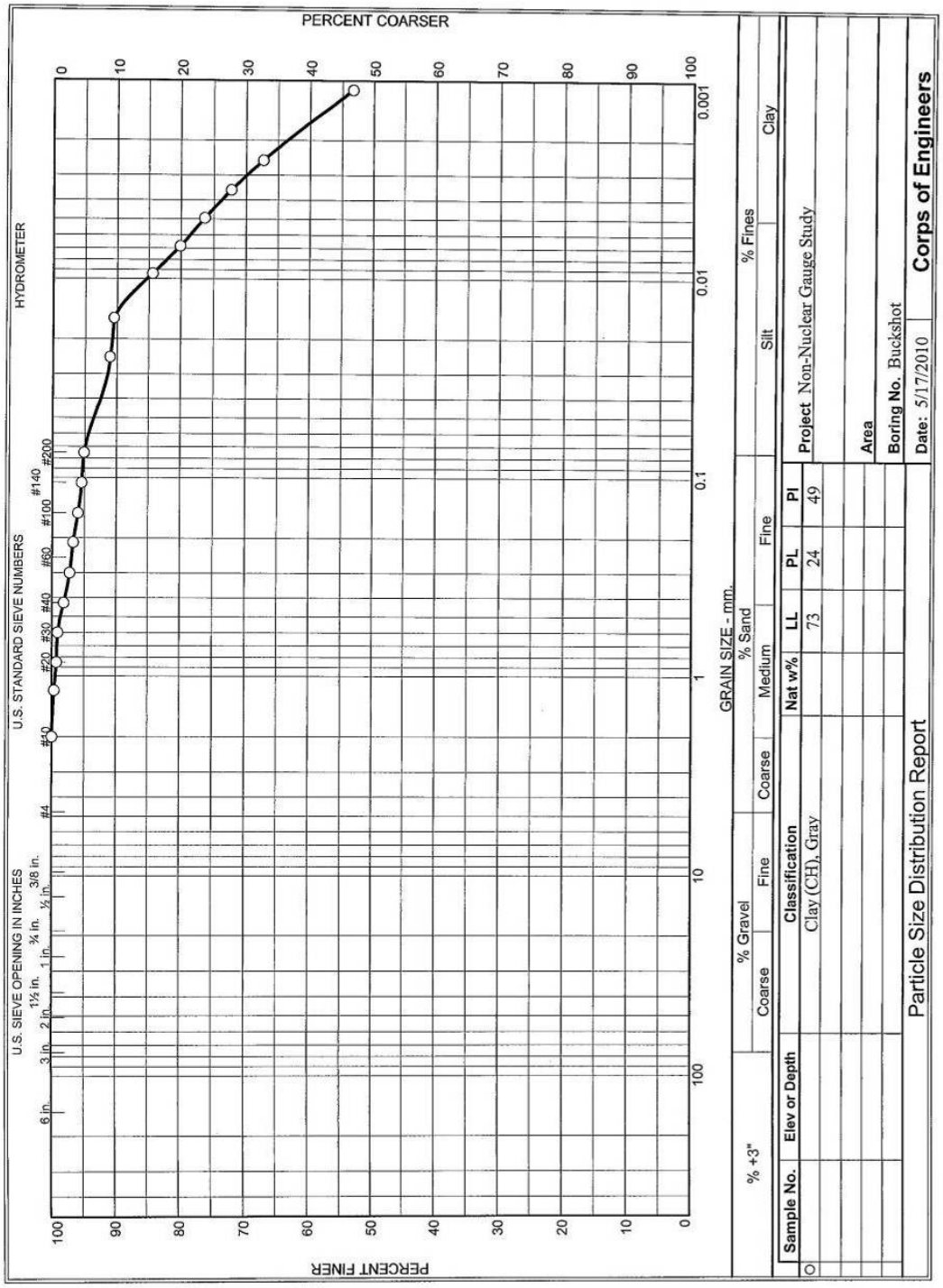
Description of soil or material excluded: _____

Remarks: _____

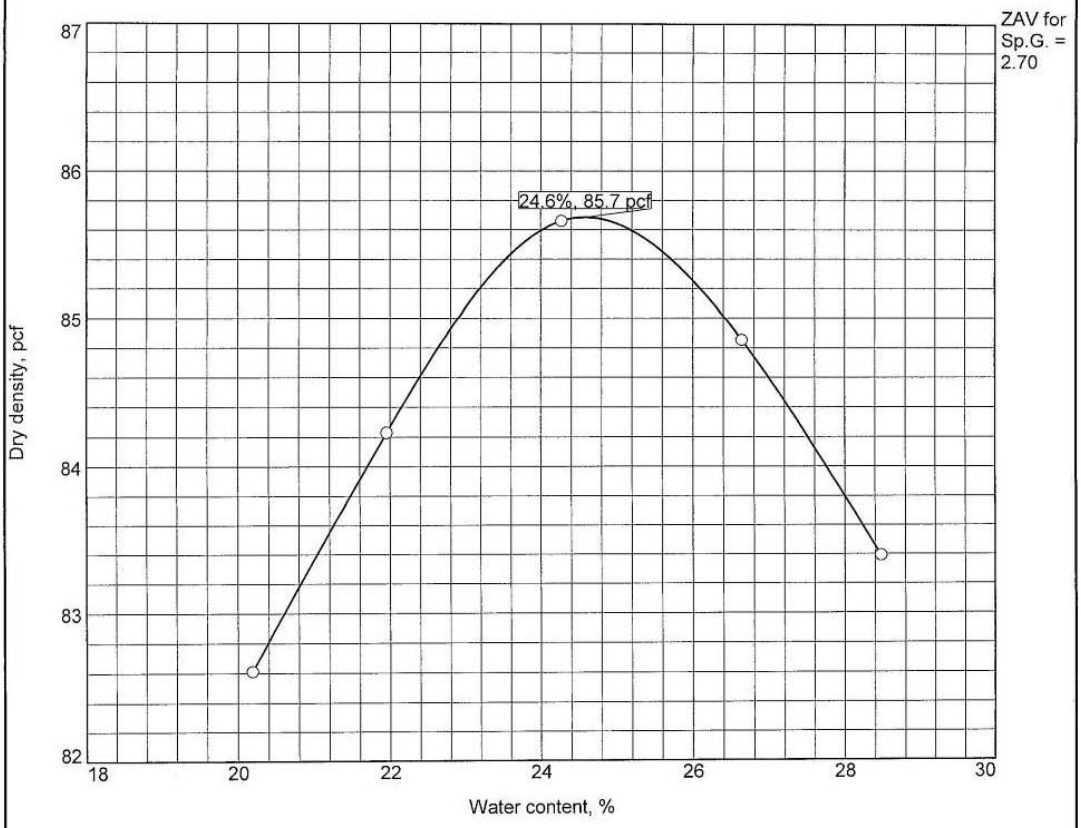
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

CH-ERDC


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Clay (CH), Gray
73
24
49
Project Non-Nuclear Gauge Study
Area
Boring No. Buckshot
Date: 5/17/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
			2.7	2.70 EST.	73	24	0.0	95.1

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 85.7 pcf Optimum moisture = 24.6 %	CLAY (CH), GRAY
Project No. MD1910 **Client:** EARNEST BARNEY **Project:** NON-NUCLEAR GAGE STUDY ○ **Source of Sample:** CLAY	**Remarks:**
Corps of Engineers **Engineer Research Development Center**	**Figure**

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 4/25/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	CH-ERDC			
Location:				
Sample No.:				
Flask No.:	12	16		
Weight dry soil after test, g, (M_s) :	76.77	70.35		
Test temp., °C:	20.5	20.5		
Average calibrated weight of flask, g, (M_p):	174.66	179.14		
Average calibrated volume of flask, ml, (Vp):	499.56	499.29		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	722.14	722.43		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99810	0.99810		
Temp. coefficient, (Table 1 (K)) :	0.99959	0.99959		
$M_{pw,t}$ =	673.27	677.48		
G_t =	2.78	2.77		
$G_{20°C}$ =	2.75	2.77		
Average $G_{20°C}$ =	2.76			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clay (CH), Gray

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

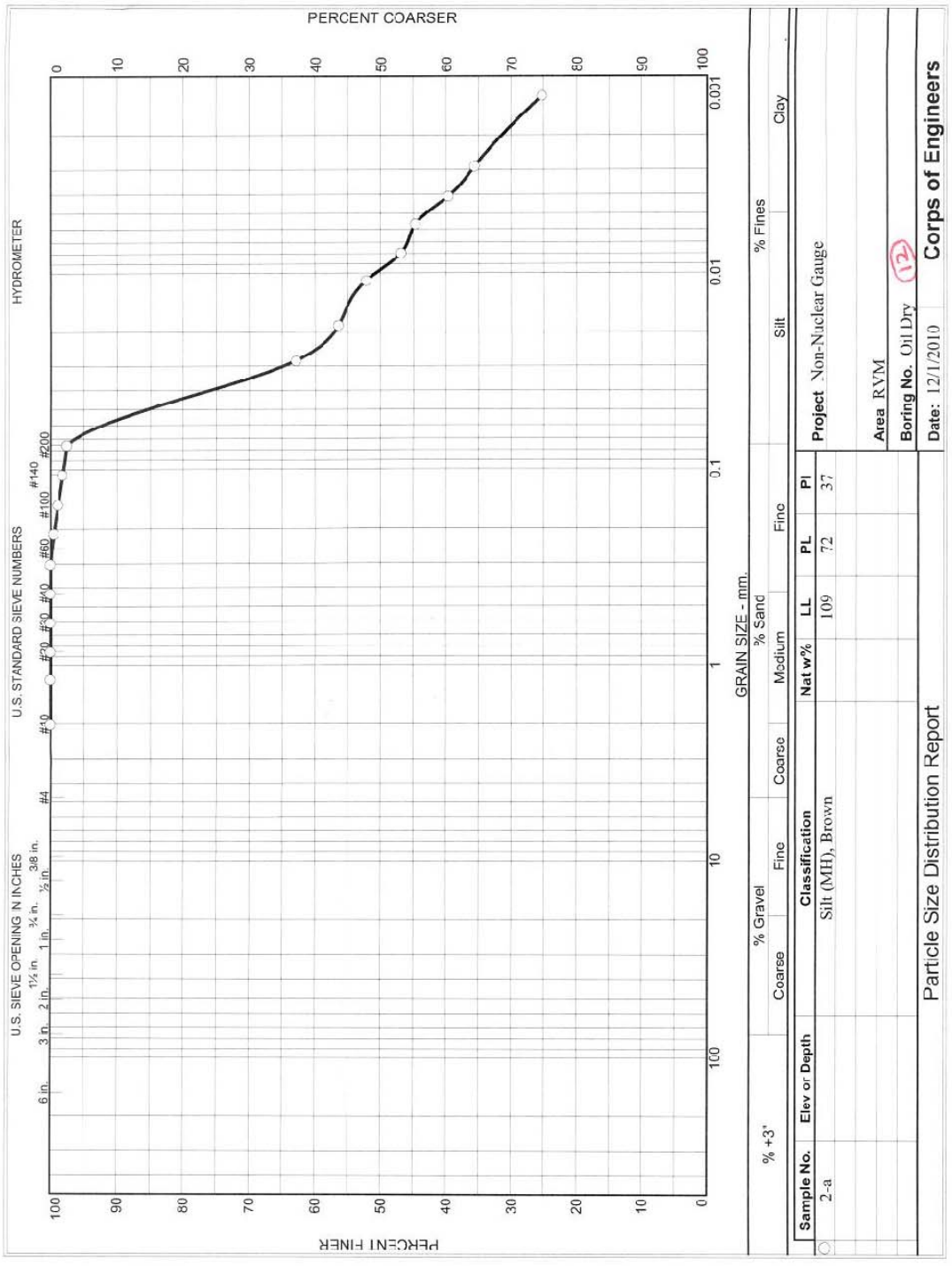
Description of soil or material excluded: _____

Remarks: _____

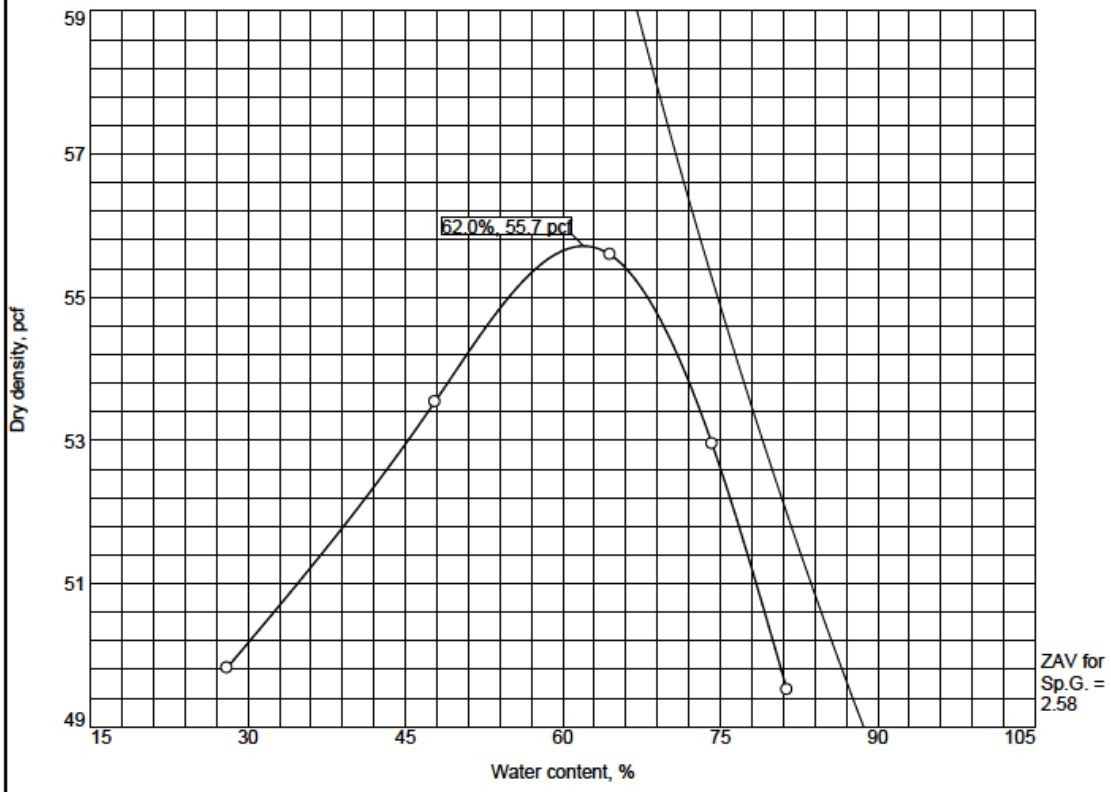
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

MH


PERCENT COARSER
PERCENT FINER
HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
⅜ in.
#4
#10
#20
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
2-a
Silt (MH), Brown
109
72
37
Project Non-Nuclear Gauge
Area RVM
Boring No. Oil Dry (12)
Date: 12/1/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-07 Method A Standard

Elev/ Depth	Classification USCS	Classification AASHTO	Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	SP			2.58 est.			0.0	0.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 55.7 pcf Optimum moisture = 62.0 %	Clay (MH), Gray

Project No. MD0411 **Client:** Mariely Mejias
Project: Non-Nuclear Denisty Gauge

○ **Source of Sample:** 2A

Corps of Engineers
Engineer Research Development Center

Remarks:
Estimated Specific Gravity
Because we had no experience with this soil type, we had to run numerous points during compaction of this soil to get a well defined curve.

Figure

Tested By: CEC **Checked By:** LRC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	MH			
Location:				
Sample No.:				
Flask No.:	28	32		
Weight dry soil after test, g, (M_s) :	43.72	41.09		
Test temp., °C:	19.5	19.6		
Average calibrated weight of flask, g, (M_p):	169.33	169.90		
Average calibrated volume of flask, ml, (Vp):	499.39	499.42		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	694.64	693.63		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99931	0.99829		
Temp. coefficient, (Table 1 (K)) :	1.00010	1.00008		
$M_{pw,t}$ =	667.87	668.46		
G_t =	2.58	2.58		
$G_{20°C}$ =	2.58	2.58		
Average $G_{20°C}$ =	2.58			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Silt (MH), Gray

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

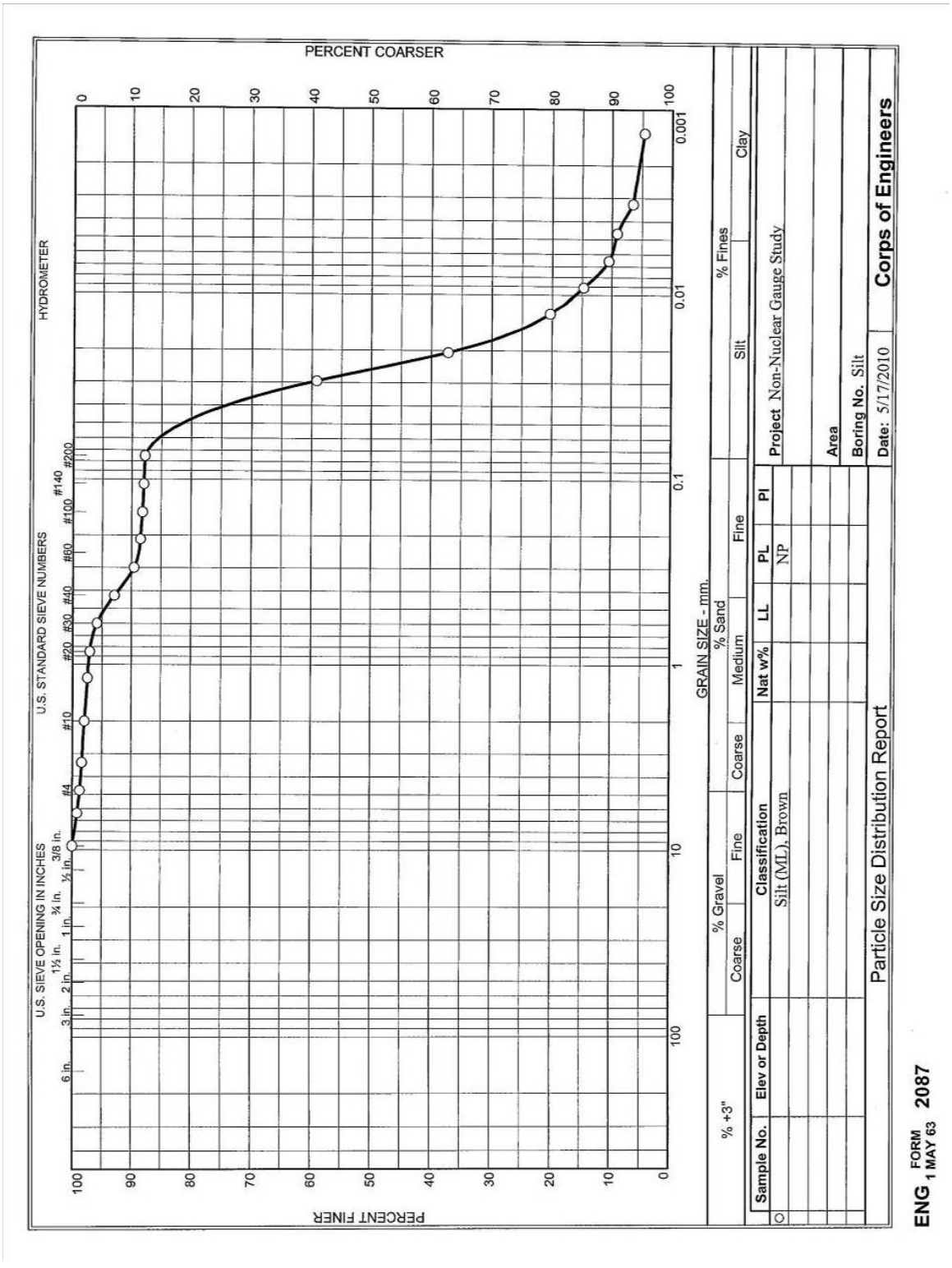
Description of soil or material excluded: _____

Remarks: _____

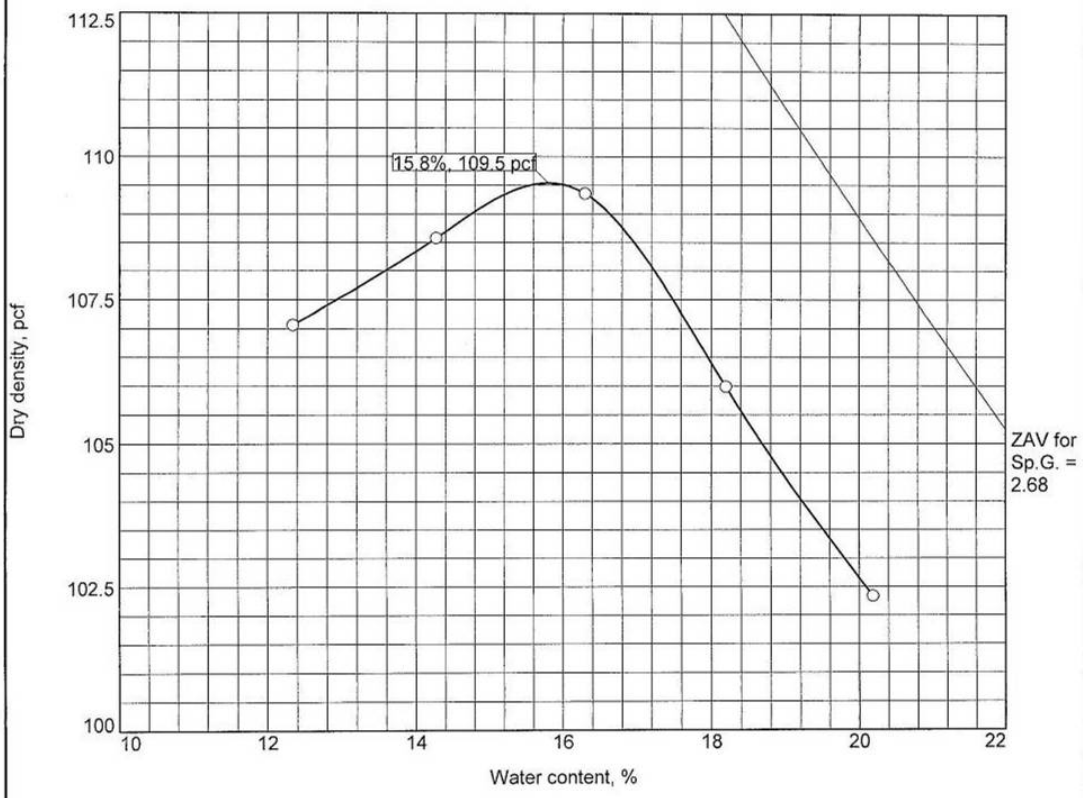
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

ML


PERCENT COARSER
PERCENT FINER
HYDROMETER
U.S. STANDARD SIEVE NUMBERS
U.S. SIEVE OPENING IN INCHES
6 in.
3 in.
2 in.
1½ in.
1 in.
¾ in.
½ in.
3/8 in.
#4
#10
#20
#30
#40
#60
#100
#140
#200
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Silt (ML), Brown
NP
Project Non-Nuclear Gauge Study
Area
Boring No. Silt
Date: 5/17/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-00a Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
			1.0	2.68 EST.	NP		1.2	87.7

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 109.5 pcf Optimum moisture = 15.8 %	SILT (ML), BROWN
Project No. MD1910 **Client:** EARNEST BARNEY **Project:** NON-NUCLEAR GAGE STUDY ○ **Source of Sample:** SILT	**Remarks:**
Corps of Engineers **Engineer Research Development Center**	**Figure**

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 2

WORK ORDER NO. MD1812 Date: 04/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	ML (Silt)			
Location:				
Sample No.:				
Flask No.:	53	57		
Weight dry soil after test, g, (M_s) :	76.23	81.27		
Test temp., °C:	20.3	20.2		
Average calibrated weight of flask, g, (M_p):	180.46	171.24		
Average calibrated volume of flask, ml, (Vp):	499.36	499.28		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	727.51	721.23		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99814	0.99816		
Temp. coefficient, (Table 1 (K)) :	0.99994	0.99996		
$M_{pw,t}$ =	676.91	669.60		
G_t =	2.76	2.74		
$G_{20°C}$ =	2.76	2.74		
Average $G_{20°C}$ =	**2.75**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Silt (ML), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

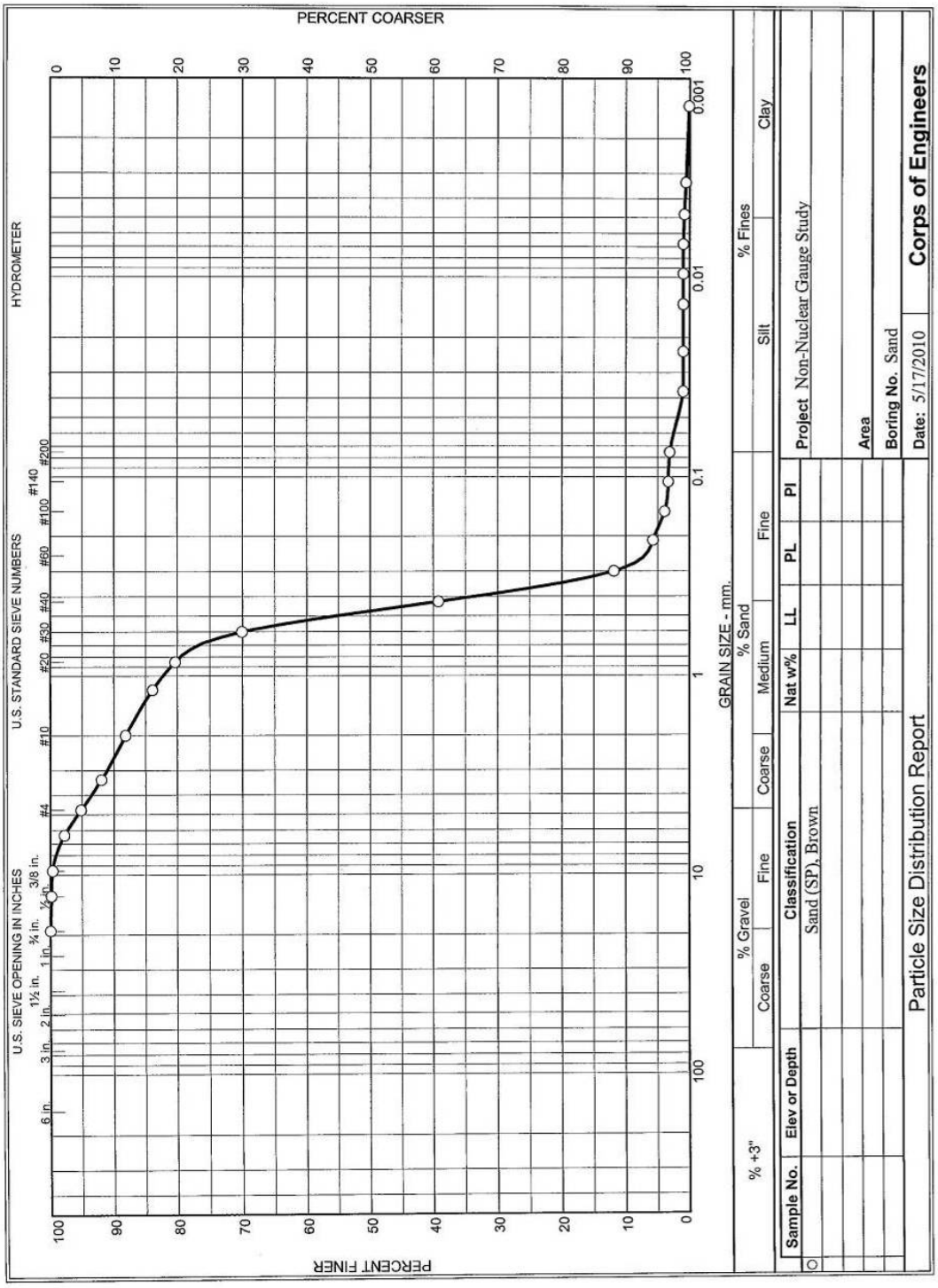
Description of soil or material excluded: _____

Remarks: _____

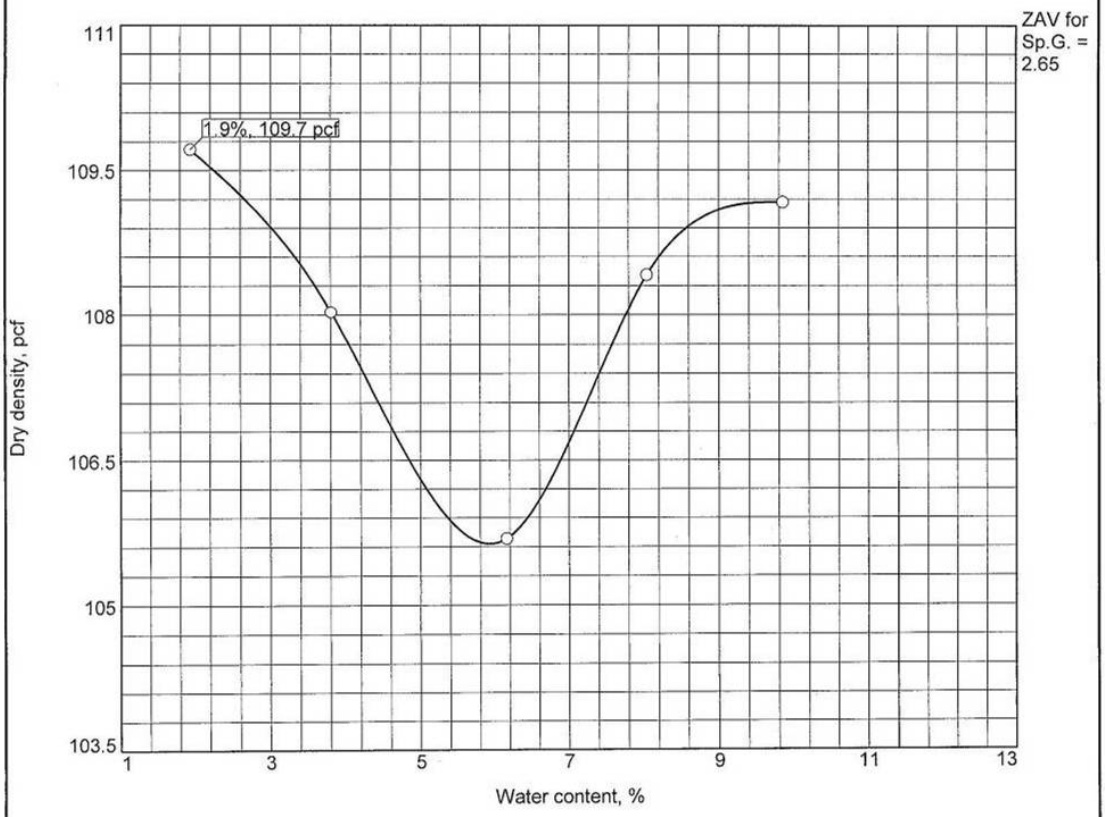
Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SP


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Sand (SP), Brown
Nat w%
LL
PL
PI
Project Non-Nuclear Gauge Study
Area
Boring No. Sand
Date: 5/17/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT



Test specification: ASTM D 698-00a Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
	SP		0.4	2.65	NP		4.9	3.1

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 109.7 pcf Optimum moisture = 1.9 %	SAND (SP), BROWN
Project No. MD1910 **Client:** EARNEST BARNEY **Project:** NON-NUCLEAR GAGE STUDY ○ **Source of Sample:** SAND	**Remarks:** SOIL SHIFTED DURING COMPACTION GRAVITY EST.
Corps of Engineers **Engineer Research Development Center**	**Figure**

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SP			
Location:				
Sample No.:				
Flask No.:	37	40		
Weight dry soil after test, g, (M_s) :	100.89	108.88		
Test temp., °C:	19.6	19.6		
Average calibrated weight of flask, g, (M_p):	177.20	174.27		
Average calibrated volume of flask, ml, (Vp):	499.34	499.44		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	738.84	740.96		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99820	0.99829		
Temp. coefficient, (Table 1 (K)) :	1.00008	1.00008		
$M_{pw,t}$ =	675.68	672.85		
G_t =	2.67	2.67		
$G_{20°C}$ =	2.67	2.67		
Average $G_{20°C}$ =	**2.67**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Sand (SP), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

Description of soil or material excluded: _____

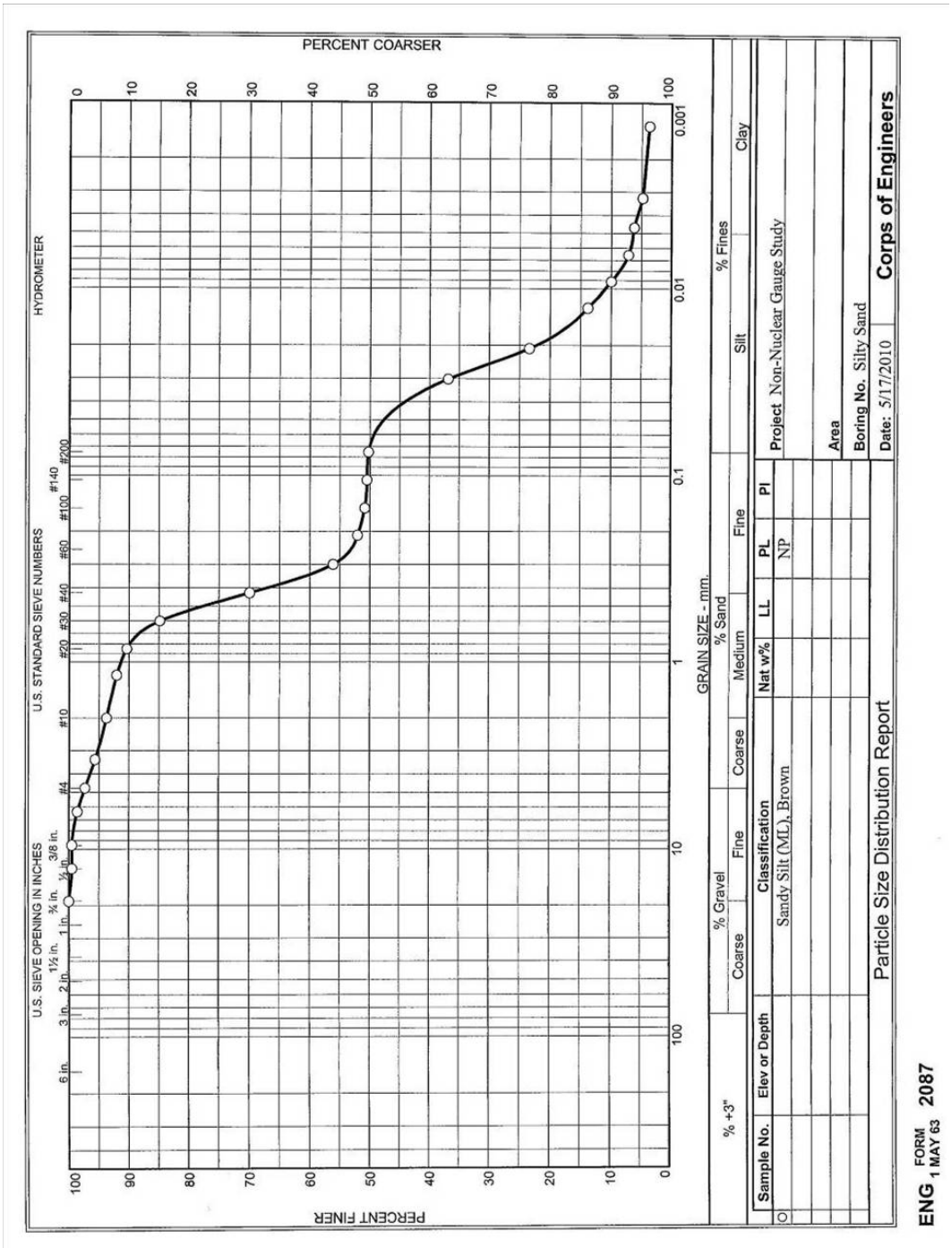
Remarks: _____

Technician: AT Computed by: AT Checked by: LRC

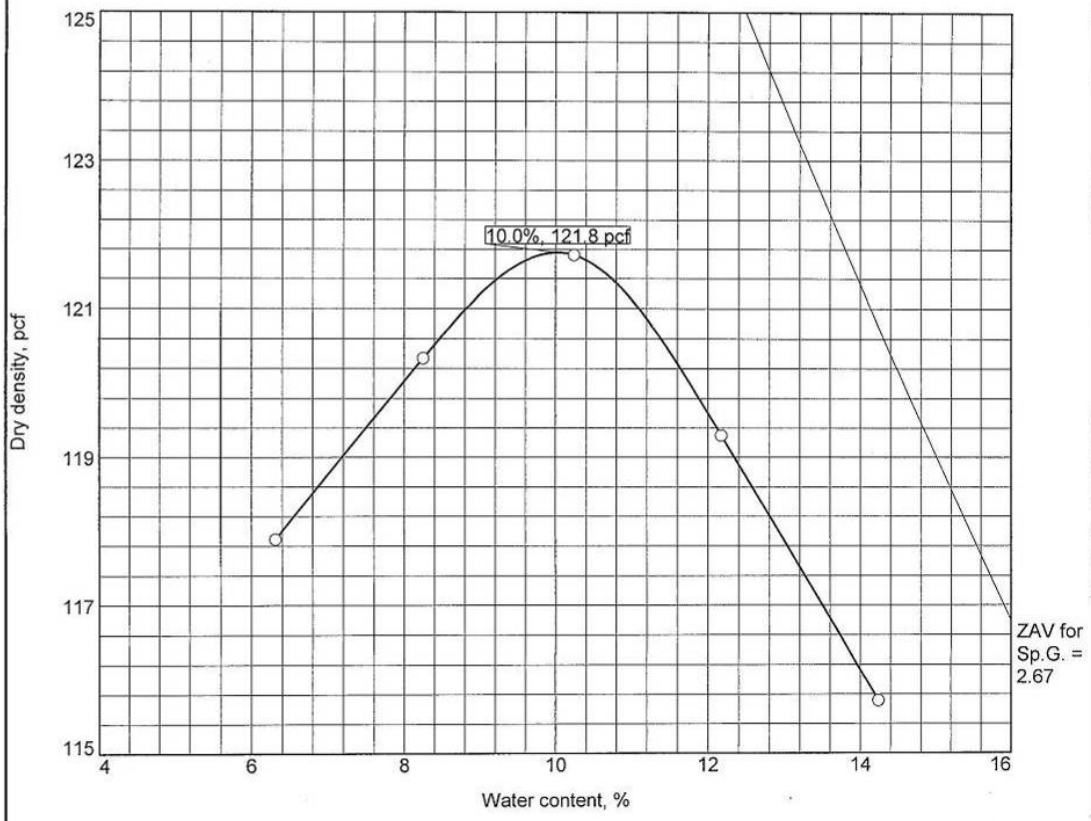
Revised 8/8/11

SM

Note: This soil was classified as Sandy-Silt (ML) by the MTC.



COMPACTION TEST REPORT



Test specification: ASTM D 698-00a Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
			0.4	2.67 EST.	NP		2.7	50.3

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 121.8 pcf Optimum moisture = 10.0 %	SANDY SILT (ML), BROWN
Project No. MD1910 **Client:** EARNEST BARNEY **Project:** NON-NUCLEAR GAGE STUDY ○ **Source of Sample:** SILTY SAND	**Remarks:**
Corps of Engineers **Engineer Research Development Center**	Figure

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	ML (SM)			
Location:				
Sample No.:				
Flask No.:	12	16		
Weight dry soil after test, g, (M_s) :	94.04	98.34		
Test temp., °C:	19.7	19.7		
Average calibrated weight of flask, g, (M_p):	167.30	173.12		
Average calibrated volume of flask, ml, (Vp):	499.41	499.32		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	725.22	733.71		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99821	0.99821		
Temp. coefficient, (Table 1 (K)) :	1.00006	1.00006		
$M_{pw,t}$ =	665.94	671.57		
G_t =	2.71	2.72		
$G_{20°C}$ =	**2.71**	**2.72**		
Average $G_{20°C}$ =	**2.71**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Silty Sand (SM), Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

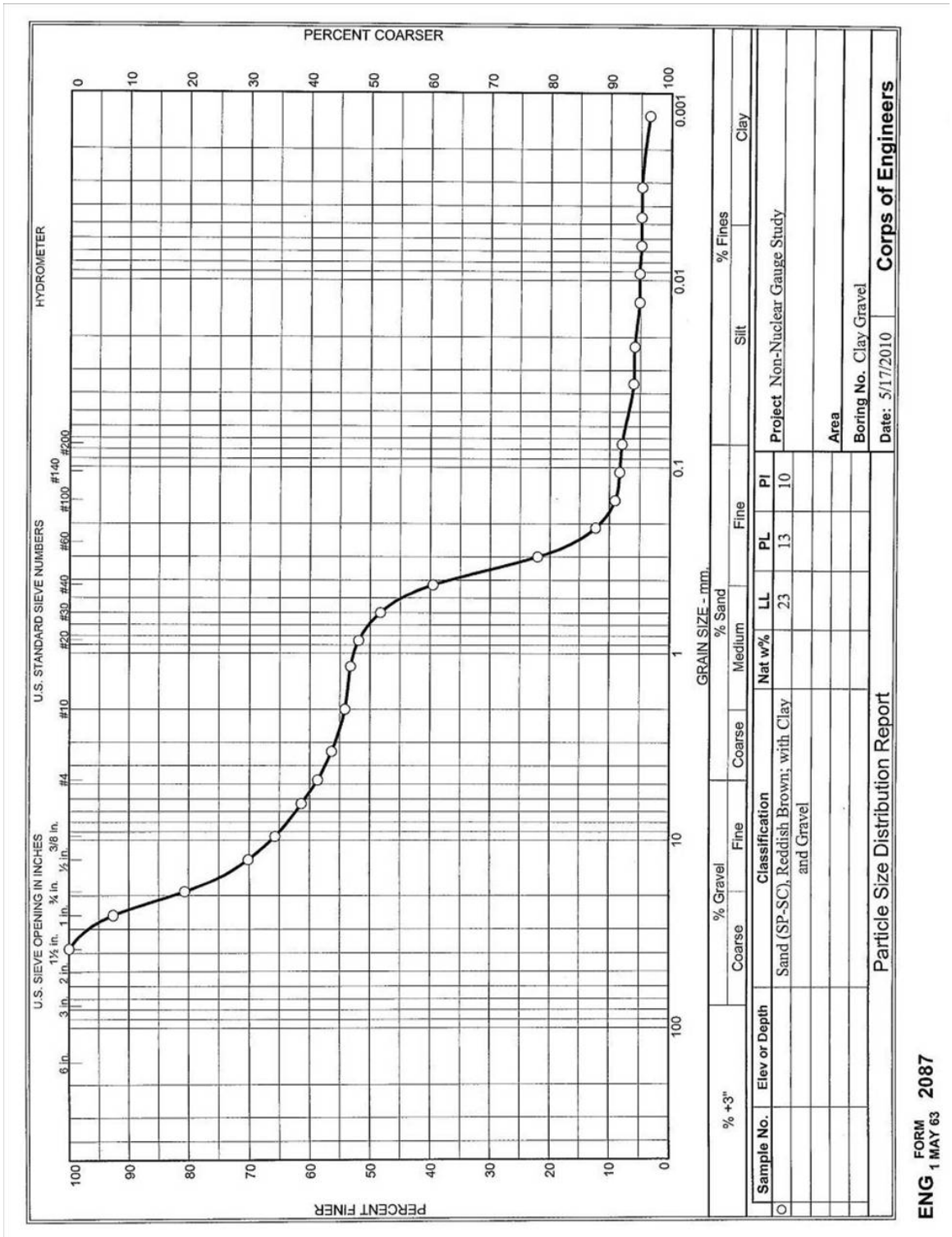
Description of soil or material excluded: _____

Remarks: _____

Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

SP-SC


PERCENT COARSER
PERCENT FINER
U.S. SIEVE OPENING IN INCHES
U.S. STANDARD SIEVE NUMBERS
HYDROMETER
GRAIN SIZE - mm.
% +3"
% Gravel
Coarse
Fine
% Sand
Coarse
Medium
Fine
% Fines
Silt
Clay
Sample No.
Elev or Depth
Classification
Nat w%
LL
PL
PI
Sand (SP-SC), Reddish Brown; with Clay and Gravel
23
13
10
Project Non-Nuclear Gauge Study
Area
Boring No. Clay Gravel
Date: 5/17/2010
Particle Size Distribution Report
Corps of Engineers
ENG FORM 1 MAY 63 2087

COMPACTION TEST REPORT

Test specification: ASTM D 698-00a Method B Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
			0.4	2.70 EST.	23	13	41.3	8.0

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 128.8 pcf Optimum moisture = 8.0 %	SAND (SP-SC), REDISH BROWN WITH CLAY AND SAND
Project No. MD1910 **Client:** EARNEST BARNEY **Project:** NON-NUCLEAR GAGE STUDY ○ **Source of Sample:** Clay Gravel	**Remarks:**
Corps of Engineers **Engineer Research Development Center**	Figure

Tested By: CEC

SPECIFIC GRAVITY OF SOILS
ASTM D 854
FLASK SET # 1

WORK ORDER NO. MD1812 Date: 4/18/12

Project: Non-Nuclear Gauge

Method A: _____ Method B: X

Boring:	SP-SC			
Location:				
Sample No.:				
Flask No.:	20	25		
Weight dry soil after test, g, (M_s) :	96.41	97.77		
Test temp., °C:	19.5	19.6		
Average calibrated weight of flask, g, (M_p):	171.39	166.90		
Average calibrated volume of flask, ml, (Vp):	499.32	499.31		
Weight of flask, water, & soil @ test temp., g, ($M_{pws,t}$):	730.42	728.40		
Density of water @ test temp., g/ml, (Table 1, ($P_{w,t}$)):	0.99831	0.99829		
Temp. coefficient, (Table 1 (K)) :	1.00010	1.00008		
$M_{pw,t}$ =	669.35	667.35		
G_t =	2.69	2.66		
$G_{20°C}$ =	2.69	2.66		
Average $G_{20°C}$ =	**2.68**			

Formulas: Weight of flask & water @ test temp., g = $M_{pw,t} = M_p + (V_p \times P_{w,t})$

Specific gravity of soil @ test temp. = $Gt = M_s/(M_{pw,t} - (M_{pws,t} - M_s))$

Specific gravity of soil @ 20°C = $K \times G_t$

Visual Classification: Clayey Sand (SC), Reddish Brown

Percent passing No. 4 sieve: 100

Was any soil or material excluded from the specimen? Yes _____ No X

Description of soil or material excluded: _____

Remarks: _____

Technician: AT Computed by: AT Checked by: LRC

Revised 8/8/11

Appendix B: Raw test data

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CL-1	15.47	102.075	15.450	88.415	112.715	2.317	110.162	0.00270	-0.2929	8.6185	0.0	0.0	87.8
CL-1	15.81	101.600	14.700	88.579	100.493	-1.012	101.520	0.00250	-0.2543	7.1922	0.0	0.0	87.8
CL-1	14.99	101.850	15.575	88.125	116.998	2.713	113.907	0.00290	-0.3064	8.8308	0.0	0.0	87.8
CL-1	15.25	100.125	15.675	86.557	116.624	3.471	112.712	0.00274	-0.3052	9.1490	0.0	0.0	87.8
CL-1	15.92	102.800	14.775	89.567	95.494	-1.842	97.285	0.00225	-0.2386	6.9430	0.0	0.0	87.8
CL-1	15.59	105.050	14.975	91.368	110.744	1.442	109.169	0.00272	-0.2866	8.2652	0.0	0.0	87.8
CL-1	16.10	105.600	15.250	91.627	114.861	2.401	112.168	0.00283	-0.2996	8.6706	0.0	0.0	87.8
CL-1	15.75	101.875	15.200	88.433	84.224	-5.686	89.302	0.00208	-0.2031	5.6060	0.0	0.0	87.8
CL-1	15.65	102.850	15.025	89.415	104.741	1.112	103.589	0.00241	-0.2677	8.0338	0.0	0.0	87.8
CL-1	15.15	106.700	15.500	92.381	118.657	3.438	114.713	0.00286	-0.3116	9.1733	0.0	0.0	87.8
CL-1	15.96	106.125	15.575	91.823	120.073	3.705	115.783	0.00290	-0.3161	9.3093	0.0	0.0	87.8
CL-1	15.60	105.400	14.575	91.992	108.918	2.033	106.748	0.00251	-0.2809	8.4505	0.0	0.0	87.8
CL-1	15.41	105.075	15.225	91.191	97.741	-1.232	98.960	0.00231	-0.2457	7.1957	0.0	0.0	87.8
CL-1	14.78	109.500	15.750	94.600	124.067	4.431	118.803	0.00300	-0.3286	9.7060	0.0	0.0	87.8
CL-1	14.68	108.600	15.775	93.803	123.233	4.285	118.169	0.00298	-0.3260	9.6403	0.0	0.0	87.8
CL-1	14.87	105.600	14.875	91.926	101.999	-0.406	102.415	0.00246	-0.2591	7.5144	0.0	0.0	87.8
CL-1	20.00	118.700	23.050	96.465	153.755	7.857	142.555	0.00400	-0.4222	12.1174	0.0	0.0	87.8
CL-1	19.99	119.450	22.450	97.550	154.667	8.148	143.014	0.00399	-0.4251	12.2949	0.0	0.0	87.8
CL-1	19.34	118.475	22.225	96.932	152.742	8.198	141.169	0.00386	-0.4190	12.2594	0.0	0.0	87.8
CL-1	19.56	117.325	22.250	95.971	152.833	8.238	141.201	0.00387	-0.4193	12.2813	0.0	0.0	87.8
CL-1	18.98	123.225	21.600	101.336	149.798	7.424	139.446	0.00387	-0.4098	11.7828	0.0	0.0	87.8
CL-1	19.04	123.925	21.550	101.954	158.108	8.256	146.050	0.00415	-0.4360	12.4618	0.0	0.0	87.8
CL-1	19.04	123.275	21.125	101.775	150.819	7.939	139.726	0.00382	-0.4130	12.0627	0.0	0.0	87.8
CL-1	19.37	122.800	21.425	101.132	146.748	7.764	136.176	0.00363	-0.4001	11.8491	0.0	0.0	87.8
CL-1	18.50	124.500	22.225	101.861	141.863	6.755	132.886	0.00357	-0.3847	11.2185	0.0	0.0	87.8
CL-1	18.38	125.125	21.050	103.366	151.632	7.953	140.460	0.00386	-0.4155	12.0971	0.0	0.0	87.8
CL-1	18.50	124.700	21.125	102.951	150.977	7.781	140.078	0.00386	-0.4135	11.9900	0.0	0.0	87.8
CL-1	18.47	123.875	20.925	102.440	147.230	7.942	136.397	0.00363	-0.4017	11.9592	0.0	0.0	87.8
CL-1	15.30	110.475	16.675	94.686	130.020	5.437	123.316	0.00316	-0.3474	10.2853	0.0	0.0	87.8
CL-1	14.53	110.175	17.100	94.086	129.406	5.185	123.027	0.00317	-0.3455	10.1690	0.0	0.0	87.8
CL-1	15.79	116.125	18.575	97.934	136.748	6.211	128.751	0.00339	-0.3686	10.8126	0.0	0.0	87.8
CL-1	16.28	112.450	17.800	95.458	128.663	5.418	122.050	0.00308	-0.3431	10.2572	0.0	0.0	87.8
CL-1	15.90	116.250	17.075	99.295	128.837	5.591	122.016	0.00305	-0.3437	10.3376	0.0	0.0	87.8
CL-1	17.62	114.200	17.375	97.295	136.071	6.144	128.194	0.00336	-0.3665	10.7719	0.0	0.0	87.8
CL-1	17.19	119.725	19.000	100.609	144.598	7.284	134.780	0.00361	-0.3934	11.5465	0.0	0.0	87.8
CL-1	14.21	118.125	17.500	100.532	127.588	5.439	121.006	0.00301	-0.3397	10.2557	0.0	0.0	87.8
CL-1	16.23	118.125	16.700	101.221	133.142	6.181	125.392	0.00319	-0.3573	10.7033	0.0	0.0	87.8
CL-1	16.33	115.625	17.600	98.321	139.566	6.642	130.873	0.00346	-0.3775	11.1071	0.0	0.0	87.8
CL-1	18.27	121.425	18.950	102.081	144.848	7.304	134.988	0.00362	-0.3942	11.5621	0.0	0.0	87.8
CL-1	16.94	119.625	17.450	101.852	132.528	6.090	124.920	0.00322	-0.3605	10.7986	0.0	0.0	87.8
CL-2	7.50	114.100	7.275	106.362	120.283	4.842	114.728	0.00271	-0.3132	9.7340	0.0	0.0	3.1
CL-2	7.54	114.250	6.400	107.378	128.101	5.972	120.882	0.00291	-0.3300	10.1028	0.0	0.0	3.1
CL-2	7.46	112.975	6.350	106.229	128.011	6.313	120.409	0.00283	-0.3297	10.2529	0.0	0.0	3.1
CL-2	7.38	113.850	6.425	106.977	123.593	5.566	117.077	0.00273	-0.3164	9.8196	0.0	0.0	3.1
CL-2	7.32	112.525	6.375	105.781	110.245	3.319	106.703	0.00237	-0.2762	8.6346	0.0	0.0	3.1
CL-2	7.25	115.850	6.525	108.754	116.422	4.436	111.477	0.00253	-0.2948	9.1825	0.0	0.0	3.1
CL-2	7.42	116.075	6.750	108.735	115.194	3.920	110.849	0.00254	-0.2911	8.9599	0.0	0.0	3.1
CL-2	7.40	115.250	5.975	108.752	107.673	2.715	104.826	0.00231	-0.2685	8.3364	0.0	0.0	3.1
CL-2	7.22	113.425	6.175	106.828	111.243	3.572	107.407	0.00243	-0.2843	8.8876	0.0	0.0	3.1
CL-2	7.16	116.850	6.400	109.821	113.277	3.724	109.210	0.00247	-0.2854	8.8334	0.0	0.0	3.1
CL-2	7.44	117.925	6.450	110.780	112.268	3.507	108.464	0.00245	-0.2823	8.7222	0.0	0.0	3.1
CL-2	7.14	113.825	6.550	106.828	105.520	2.409	103.038	0.00224	-0.2620	8.1900	0.0	0.0	3.1
CL-2	2.42	105.875	1.500	104.310	92.502	-0.325	92.804	0.00186	-0.2228	7.1621	0.0	0.0	3.1
CL-2	2.33	108.025	1.200	106.744	96.745	1.018	95.770	0.00196	-0.2356	7.6179	0.0	0.0	3.1
CL-2	2.21	106.500	1.125	105.315	87.597	-1.917	89.309	0.00181	-0.2081	6.5010	0.0	0.0	3.1
CL-2	2.44	105.550	1.325	104.170	88.346	-1.750	89.920	0.00180	-0.2103	6.6544	0.0	0.0	3.1
CL-2	2.34	107.600	1.250	106.272	92.392	-0.477	92.835	0.00186	-0.2225	7.1385	0.0	0.0	3.1
CL-2	2.51	110.500	1.275	109.109	101.425	2.221	99.220	0.00206	-0.2497	8.1189	0.0	0.0	3.1
CL-2	2.26	111.475	1.350	109.990	95.404	0.463	94.965	0.00200	-0.2378	7.5977	0.0	0.0	3.1
CL-2	2.06	108.450	1.050	107.323	98.935	1.740	97.242	0.00198	-0.2422	7.8947	0.0	0.0	3.1
CL-2	2.19	109.825	1.150	108.576	97.994	1.199	96.833	0.00201	-0.2394	7.6704	0.0	0.0	3.1
CL-2	2.27	107.350	1.075	106.208	91.948	-0.652	92.551	0.00189	-0.2212	6.9399	0.0	0.0	3.1
CL-2	2.06	108.750	1.025	107.647	85.867	-2.109	87.717	0.00172	-0.2029	6.5036	0.0	0.0	3.1

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CH-1	10.44	113.175	8.675	104.141	99.017	0.179	98.840	0.00221	-0.2497	7.6367	0.0	0.0	50.3
CH-1	10.52	113.775	9.000	104.381	110.207	2.509	107.510	0.00253	-0.2849	8.6663	0.0	0.0	50.3
CH-1	9.50	111.900	8.125	103.491	109.073	2.244	106.679	0.00252	-0.2824	8.5694	0.0	0.0	50.3
CH-1	9.99	117.550	8.950	107.894	109.457	2.604	106.679	0.00246	-0.2826	8.6934	0.0	0.0	50.3
CH-1	10.25	116.700	8.825	107.236	102.347	0.981	101.353	0.00228	-0.2602	7.9767	0.0	0.0	50.3
CH-1	10.12	119.175	9.500	108.836	112.885	2.918	109.685	0.00263	-0.2934	8.8603	0.0	0.0	50.3
CH-1	10.05	112.200	8.675	103.244	109.162	2.202	106.810	0.00252	-0.2816	8.5188	0.0	0.0	50.3
CH-1	10.06	112.900	8.475	104.079	108.761	2.261	106.357	0.00248	-0.2804	8.5382	0.0	0.0	50.3
CH-1	10.34	119.775	9.025	109.860	99.187	0.198	98.991	0.00220	-0.2502	7.6427	0.0	0.0	50.3
CH-1	10.17	121.000	9.200	110.806	114.574	3.287	110.928	0.00268	-0.2987	9.0393	0.0	0.0	50.3
CH-1	10.11	117.675	8.425	108.531	111.314	2.455	108.646	0.00261	-0.2884	8.6598	0.0	0.0	50.3
CH-1	9.94	122.000	9.575	111.339	108.795	2.262	106.389	0.00254	-0.2865	8.7053	0.0	0.0	50.3
CH-1	13.96	142.625	11.375	128.058	117.890	2.930	114.534	0.00299	-0.3091	8.9367	0.0	0.0	50.3
CH-1	12.90	137.975	12.150	123.027	122.424	4.277	117.402	0.00298	-0.3234	9.6032	0.0	0.0	50.3
CH-1	13.95	143.900	12.425	127.996	115.632	2.810	112.471	0.00286	-0.3020	8.8593	0.0	0.0	50.3
CH-1	13.56	144.550	11.650	129.467	119.220	3.838	114.813	0.00289	-0.3133	9.3674	0.0	0.0	50.3
CH-1	13.40	128.875	13.200	113.847	114.744	3.511	110.852	0.00263	-0.2992	9.1513	0.0	0.0	50.3
CH-1	13.64	129.775	13.100	114.744	106.546	0.922	105.573	0.00256	-0.2734	8.0825	0.0	0.0	50.3
CH-1	14.36	127.600	13.700	112.225	110.796	2.681	107.904	0.00255	-0.2868	8.7573	0.0	0.0	50.3
CH-1	13.32	131.000	12.325	116.626	119.817	3.900	115.319	0.00288	-0.3152	9.3929	0.0	0.0	50.3
CH-1	13.79	125.925	12.600	111.834	116.544	3.147	112.988	0.00281	-0.3049	9.0631	0.0	0.0	50.3
CH-1	13.92	128.675	13.225	113.645	100.199	-1.625	101.855	0.00240	-0.2534	7.3526	0.0	0.0	50.3
CH-1	13.18	129.500	12.550	115.060	120.306	4.431	115.201	0.00283	-0.3168	9.6493	0.0	0.0	50.3
CH-1	5.65	107.450	4.675	102.651	81.678	-4.689	85.696	0.00176	-0.1950	5.9585	0.0	0.0	50.3
CH-1	5.66	108.500	4.325	104.002	89.323	-2.566	91.675	0.00200	-0.2191	6.6782	0.0	0.0	50.3
CH-1	6.02	108.175	4.650	103.368	85.261	-3.744	88.577	0.00192	-0.2063	6.2301	0.0	0.0	50.3
CH-1	6.22	107.975	4.550	103.276	81.608	-5.022	85.924	0.00181	-0.1948	5.8625	0.0	0.0	50.3
CH-1	5.98	111.075	4.800	105.988	82.804	-4.375	86.593	0.00180	-0.1986	6.0402	0.0	0.0	50.3
CH-1	5.48	110.600	4.400	105.939	92.812	-1.650	94.369	0.00207	-0.2301	7.0829	0.0	0.0	50.3
CH-1	6.01	110.150	4.750	105.155	93.389	-1.543	94.853	0.00208	-0.2319	7.1341	0.0	0.0	50.3
CH-1	5.81	109.775	4.300	105.249	77.812	-6.764	83.457	0.00172	-0.1828	5.4301	0.0	0.0	50.3
CH-1	5.85	111.350	4.650	106.402	94.208	-0.849	95.015	0.00206	-0.2345	7.2985	0.0	0.0	50.3
CH-1	5.58	111.300	4.275	106.737	83.350	-4.364	87.153	0.00183	-0.2003	6.0790	0.0	0.0	50.3
CH-1	5.86	112.300	4.675	107.284	107.097	2.410	104.577	0.00237	-0.2751	8.7237	0.0	0.0	50.3
CH-1	5.95	111.875	4.300	107.263	81.586	-5.396	86.239	0.00179	-0.1947	5.8430	0.0	0.0	50.3
SC-1	52.39	68.225	37.475	49.627	89.301	14.020	78.321	0.00170	-0.0569	-0.1805	37.0	72.0	97.5
SC-1	53.04	71.000	35.250	52.495	119.029	19.799	99.358	0.00424	-0.3931	10.6370	37.0	72.0	97.5
SC-1	53.98	70.400	37.100	51.349	110.695	17.452	94.247	0.00350	-0.2989	7.8758	37.0	72.0	97.5
SC-1	53.24	69.725	37.575	50.681	112.297	19.379	94.067	0.00334	-0.3170	8.8124	37.0	72.0	97.5
SC-1	51.94	71.675	39.425	51.408	122.870	21.254	101.332	0.00403	-0.4366	13.0157	37.0	72.0	97.5
SC-1	52.99	73.375	36.450	53.774	135.240	22.650	110.265	0.00522	-0.5765	17.3644	37.0	72.0	97.5
SC-1	52.47	72.750	37.150	53.044	126.079	21.210	104.017	0.00458	-0.4729	13.6879	37.0	72.0	97.5
SC-1	54.27	60.375	44.875	41.674	120.661	20.707	99.962	0.00400	-0.4116	11.9250	37.0	72.0	97.5
SC-1	51.56	71.725	40.325	51.113	127.328	21.988	104.378	0.00435	-0.4870	14.8256	37.0	72.0	97.5
SC-1	52.39	71.525	35.975	52.602	133.916	22.352	109.451	0.00518	-0.5615	16.7459	37.0	72.0	97.5
SC-1	52.77	72.200	40.275	51.470	128.939	21.504	106.119	0.00483	-0.5052	14.7137	37.0	72.0	97.5
SC-1	53.95	69.775	40.600	49.627	121.783	21.047	100.609	0.00401	-0.4243	12.4946	37.0	72.0	97.5
SC-1	62.03	75.425	47.625	51.092	144.205	23.821	116.462	0.00581	-0.6779	20.9400	37.0	72.0	97.5
SC-1	60.83	74.950	53.175	48.931	154.891	24.704	124.207	0.00685	-0.7987	24.6978	37.0	72.0	97.5
SC-1	66.94	79.550	53.975	51.664	153.416	24.737	122.991	0.00662	-0.7820	24.3729	37.0	72.0	97.5
SC-1	65.55	74.900	51.350	49.488	140.629	23.687	113.698	0.00539	-0.6374	19.8786	37.0	72.0	97.5
SC-1	64.74	75.375	47.550	51.084	147.432	23.981	118.915	0.00618	-0.7144	21.9608	37.0	72.0	97.5
SC-1	63.09	76.625	58.250	48.420	154.781	24.607	124.215	0.00687	-0.7975	24.5515	37.0	72.0	97.5
SC-1	66.20	80.375	55.450	51.705	152.535	24.478	122.539	0.00662	-0.7721	23.8382	37.0	72.0	97.5
SC-1	64.05	76.125	53.375	49.633	143.470	23.838	115.853	0.00571	-0.6695	20.7526	37.0	72.0	97.5
SC-1	63.39	76.025	49.800	50.751	147.412	24.045	118.838	0.00614	-0.7141	22.0177	37.0	72.0	97.5
SC-1	63.27	76.175	63.000	46.733	153.941	24.537	123.610	0.00679	-0.7880	24.2409	37.0	72.0	97.5
SC-1	63.22	80.450	56.100	51.537	150.381	24.278	121.003	0.00643	-0.7477	23.0437	37.0	72.0	97.5
SC-1	63.72	76.325	56.125	48.887	142.611	23.779	115.214	0.00562	-0.6598	20.4670	37.0	72.0	97.5
SC-1	74.54	78.250	62.900	48.036	144.562	23.837	116.736	0.00579	-0.6819	21.2096	37.0	72.0	97.5
SC-1	75.14	83.350	61.775	51.522	159.992	24.864	128.132	0.00742	-0.8564	26.2723	37.0	72.0	97.5
SC-1	70.19	79.325	56.350	50.736	151.990	24.398	122.180	0.00659	-0.7659	23.5986	37.0	72.0	97.5
SC-1	73.40	80.600	59.975	50.383	140.702	23.592	113.845	0.00543	-0.6382	19.8193	37.0	72.0	97.5
SC-1	74.30	80.450	66.775	48.239	140.261	23.595	113.485	0.00535	-0.6333	19.7660	37.0	72.0	97.5
SC-1	77.17	85.450	64.675	51.890	152.538	24.410	122.609	0.00665	-0.7721	23.7745	37.0	72.0	97.5
SC-1	71.83	81.175	60.950	50.435	150.137	24.343	120.744	0.00634	-0.7449	23.1140	37.0	72.0	97.5
SC-1	73.66	81.875	60.000	51.172	148.292	24.283	119.318	0.00616	-0.7241	22.4895	37.0	72.0	97.5
SC-1	75.34	81.200	69.250	47.976	131.178	22.901	106.734	0.00442	-0.5305	16.7241	37.0	72.0	97.5
SC-1	79.32	85.975	66.600	51.606	151.602	24.320	121.945	0.00654	-0.7615	23.4289	37.0	72.0	97.5
SC-1	75.90	81.300	60.575	50.631	161.211	24.969	129.000	0.00749	-0.8702	26.7934	37.0	72.0	97.5
SC-1	75.20	82.750	61.650	51.191	139.732	23.629	113.026	0.00529	-0.6273	19.5812	37.0	72.0	97.5

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CH-2	5.36	113.175	4.975	107.811	104.385	19.231	87.548	0.00206	-0.2275	6.8965	13.0	10.0	50.7
CH-2	5.86	113.050	5.100	107.564	105.744	19.533	88.464	0.00217	-0.2429	7.4827	13.0	10.0	50.7
CH-2	5.50	113.550	5.500	107.630	104.049	19.107	87.357	0.00205	-0.2237	6.7124	13.0	10.0	50.7
CH-2	6.25	114.025	4.975	108.621	105.093	19.353	88.053	0.00213	-0.2355	7.1580	13.0	10.0	50.7
CH-2	5.35	116.225	5.200	110.480	104.247	19.228	87.435	0.00203	-0.2259	6.8636	13.0	10.0	50.7
CH-2	5.63	116.750	5.150	111.032	104.672	19.277	87.755	0.00210	-0.2307	7.0058	13.0	10.0	50.7
CH-2	4.92	115.775	5.350	109.896	104.434	19.208	87.607	0.00208	-0.2281	6.8848	13.0	10.0	50.7
CH-2	5.51	117.700	5.175	111.909	105.362	19.488	88.178	0.00211	-0.2385	7.3392	13.0	10.0	50.7
CH-2	5.19	116.925	4.775	111.596	104.353	19.235	87.519	0.00205	-0.2271	6.8951	13.0	10.0	50.7
CH-2	5.61	116.450	4.775	111.143	105.393	19.488	88.204	0.00214	-0.2389	7.3524	13.0	10.0	50.7
CH-2	5.79	116.300	5.000	110.762	104.400	19.237	87.557	0.00207	-0.2277	6.9045	13.0	10.0	50.7
CH-2	6.38	118.600	5.025	112.925	104.837	19.337	87.849	0.00209	-0.2326	7.0886	13.0	10.0	50.7
CH-2	8.00	127.600	7.675	118.505	109.678	20.020	91.383	0.00255	-0.2874	8.7673	13.0	10.0	50.7
CH-2	7.88	124.225	7.950	115.076	111.565	20.180	92.831	0.00279	-0.3087	9.3442	13.0	10.0	50.7
CH-2	7.83	122.050	7.350	113.694	108.341	19.812	90.426	0.00244	-0.2722	8.2816	13.0	10.0	50.7
CH-2	9.10	122.850	8.100	113.645	108.137	19.869	90.213	0.00237	-0.2699	8.3100	13.0	10.0	50.7
CH-2	7.27	130.450	7.950	120.843	108.326	19.719	90.484	0.00245	-0.2721	8.1922	13.0	10.0	50.7
CH-2	9.19	126.550	8.100	117.068	109.699	19.766	91.594	0.00266	-0.2876	8.5326	13.0	10.0	50.7
CH-2	8.12	126.150	7.525	117.322	110.902	20.185	92.276	0.00268	-0.3012	9.2018	13.0	10.0	50.7
CH-2	8.52	128.675	7.950	119.199	102.629	18.807	86.383	0.00193	-0.2076	6.1940	13.0	10.0	50.7
CH-2	8.24	131.575	6.800	123.198	109.052	19.775	91.047	0.00254	-0.2803	8.4000	13.0	10.0	50.7
CH-2	7.25	131.250	7.125	122.520	109.583	19.650	91.586	0.00269	-0.2863	8.3971	13.0	10.0	50.7
CH-2	7.82	129.700	6.825	121.414	113.141	20.749	93.700	0.00284	-0.3265	10.2387	13.0	10.0	50.7
CH-2	7.26	130.050	6.975	121.570	110.785	20.374	92.034	0.00260	-0.2999	9.3598	13.0	10.0	50.7
CH-2	10.96	130.725	10.525	118.276	111.298	20.058	92.703	0.00280	-0.3057	9.1590	13.0	10.0	50.7
CH-2	11.63	132.750	10.425	120.217	111.743	20.084	93.054	0.00284	-0.3107	9.2823	13.0	10.0	50.7
CH-2	10.59	133.825	10.850	120.726	112.067	20.072	93.333	0.00291	-0.3144	9.3433	13.0	10.0	50.7
CH-2	10.80	130.100	9.925	118.353	111.738	20.175	92.980	0.00283	-0.3107	9.3911	13.0	10.0	50.7
CH-2	10.62	134.125	10.125	121.793	111.400	20.173	92.700	0.00275	-0.3068	9.2938	13.0	10.0	50.7
CH-2	11.35	132.875	10.400	120.358	111.130	19.950	92.648	0.00279	-0.3038	9.0190	13.0	10.0	50.7
CH-2	11.14	131.150	10.400	118.795	111.922	20.302	93.035	0.00278	-0.3127	9.5330	13.0	10.0	50.7
CH-2	10.99	130.075	10.475	117.742	109.113	20.071	90.874	0.00244	-0.2810	8.6928	13.0	10.0	50.7
CH-2	10.87	134.850	10.125	122.452	111.516	20.060	92.883	0.00282	-0.3081	9.2085	13.0	10.0	50.7
CH-2	11.56	132.450	10.275	120.109	110.156	19.949	91.836	0.00264	-0.2928	8.8048	13.0	10.0	50.7
CH-2	10.55	132.250	10.175	120.036	109.776	19.925	91.538	0.00261	-0.2885	8.6991	13.0	10.0	50.7
CH-2	10.52	132.800	10.225	120.481	108.930	19.908	90.844	0.00247	-0.2789	8.5002	13.0	10.0	50.7
SC-2	8.60	96.700	8.700	88.960	105.649	19.399	88.484	0.00215	-0.2418	7.3186	14.0	13.0	56.9
SC-2	8.18	96.500	8.575	88.879	106.020	19.336	88.842	0.00224	-0.2460	7.3508	14.0	13.0	56.9
SC-2	8.30	96.875	8.750	89.080	104.711	18.917	88.054	0.00220	-0.2312	6.6818	14.0	13.0	56.9
SC-2	8.80	97.450	8.850	89.527	107.117	19.520	89.623	0.00234	-0.2584	7.7453	14.0	13.0	56.9
SC-2	8.49	100.000	9.000	91.743	108.921	19.637	91.043	0.00255	-0.2788	8.2415	14.0	13.0	56.9
SC-2	8.27	97.525	9.075	89.411	109.442	19.851	91.315	0.00258	-0.2847	8.5630	14.0	13.0	56.9
SC-2	9.20	97.025	9.075	88.953	106.224	19.008	89.258	0.00239	-0.2483	7.0773	14.0	13.0	56.9
SC-2	9.05	103.425	8.825	95.038	110.392	19.953	92.030	0.00266	-0.2954	8.8641	14.0	13.0	56.9
SC-2	9.40	104.525	9.175	95.741	109.539	19.712	91.503	0.00261	-0.2858	8.4456	14.0	13.0	56.9
SC-2	8.18	102.350	8.575	94.267	109.199	19.687	91.237	0.00258	-0.2819	8.3494	14.0	13.0	56.9
SC-2	8.68	92.800	9.500	84.749	106.280	19.071	89.258	0.00237	-0.2489	7.1482	14.0	13.0	56.9
SC-2	8.47	104.400	9.200	95.604	110.752	19.890	92.377	0.00272	-0.2995	8.8791	14.0	13.0	56.9
SC-2	13.98	126.050	16.625	108.081	119.030	20.695	98.620	0.00362	-0.3931	11.5061	14.0	13.0	56.9
SC-2	13.61	111.300	15.625	96.259	119.580	20.908	98.901	0.00361	-0.3994	11.8434	14.0	13.0	56.9
SC-2	14.05	109.425	14.125	95.882	119.874	20.673	99.338	0.00376	-0.4027	11.6686	14.0	13.0	56.9
SC-2	13.47	114.575	14.725	99.869	114.431	20.640	94.853	0.00297	-0.3411	10.4246	14.0	13.0	56.9
SC-2	14.13	123.925	15.650	107.155	119.496	20.774	98.942	0.00366	-0.3984	11.6907	14.0	13.0	56.9
SC-2	13.43	117.875	15.375	102.167	120.149	20.938	99.348	0.00368	-0.4058	12.0031	14.0	13.0	56.9
SC-2	13.72	116.000	14.375	101.421	121.360	20.864	100.410	0.00389	-0.4195	12.1992	14.0	13.0	56.9
SC-2	12.95	120.475	14.200	105.495	114.028	20.628	94.529	0.00294	-0.3378	10.3227	14.0	13.0	56.9
SC-2	11.19	103.925	11.525	93.185	113.577	20.370	94.356	0.00295	-0.3315	9.9624	14.0	13.0	56.9
SC-2	10.71	103.475	12.700	91.815	112.863	20.287	93.828	0.00288	-0.3234	9.7250	14.0	13.0	56.9
SC-2	11.23	99.875	11.800	89.334	115.054	20.629	95.378	0.00308	-0.3482	10.5528	14.0	13.0	56.9
SC-2	11.19	100.525	12.650	89.237	112.870	20.287	93.834	0.00288	-0.3235	9.7269	14.0	13.0	56.9
SC-2	10.82	103.400	12.400	91.993	116.389	20.535	96.561	0.00330	-0.3633	10.7512	14.0	13.0	56.9
SC-2	10.55	103.100	12.300	91.808	116.991	20.565	97.036	0.00338	-0.3701	10.9156	14.0	13.0	56.9
SC-2	10.64	106.475	12.650	94.518	116.343	20.488	96.559	0.00331	-0.3627	10.6961	14.0	13.0	56.9
SC-2	10.50	103.775	12.150	92.532	117.678	21.102	97.172	0.00329	-0.3778	11.6099	14.0	13.0	56.9
SC-2	10.66	104.425	12.325	92.967	118.842	20.661	98.493	0.00312	-0.3462	10.3028	14.0	13.0	56.9
SC-2	10.68	104.050	12.325	92.633	115.468	20.447	95.867	0.00320	-0.3528	10.4583	14.0	13.0	56.9
SC-2	11.64	108.875	13.250	96.137	114.722	20.353	95.321	0.00313	-0.3444	10.2027	14.0	13.0	56.9
SC-2	10.87	106.600	12.225	94.988	113.456	20.322	94.293	0.00295	-0.3301	9.8907	14.0	13.0	56.9

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CH-3	11.10	96.875	9.900	88.148	138.900	23.222	112.723	0.00538	-0.6179	18.8959	28.0	11.0	64.1
CH-3	11.60	94.750	9.750	86.333	136.467	22.780	111.148	0.00526	-0.5903	17.8054	28.0	11.0	64.1
CH-3	12.36	94.125	9.825	85.705	137.565	22.788	112.034	0.00541	-0.6028	18.0834	28.0	11.0	64.1
CH-3	11.42	96.325	10.075	87.509	134.973	22.888	109.834	0.00499	-0.5734	17.5644	28.0	11.0	64.1
CH-3	11.57	99.075	10.325	89.803	144.143	23.589	116.631	0.00594	-0.6772	20.6153	28.0	11.0	64.1
CH-3	11.64	98.325	9.800	89.549	143.998	23.307	116.781	0.00606	-0.6755	20.2546	28.0	11.0	64.1
CH-3	11.14	96.700	10.900	87.196	143.543	23.288	116.429	0.00601	-0.6704	20.1153	28.0	11.0	64.1
CH-3	11.98	96.700	10.250	87.710	141.437	23.449	114.572	0.00562	-0.6466	19.7870	28.0	11.0	64.1
CH-3	11.15	102.700	10.650	92.815	142.512	23.542	115.355	0.00573	-0.6587	20.1551	28.0	11.0	64.1
CH-3	12.94	99.850	10.025	90.752	144.133	23.303	116.894	0.00608	-0.6770	20.2832	28.0	11.0	64.1
CH-3	11.11	97.825	10.400	88.610	144.779	23.390	117.335	0.00613	-0.6843	20.5377	28.0	11.0	64.1
CH-3	11.54	102.600	10.325	92.998	142.784	23.652	115.473	0.00571	-0.6618	20.3526	28.0	11.0	64.1
CH-3	16.85	99.525	14.150	87.188	139.321	23.567	112.749	0.00527	-0.6226	19.4004	28.0	11.0	64.1
CH-3	14.59	95.200	13.175	84.118	143.809	23.755	116.205	0.00580	-0.6734	20.7321	28.0	11.0	64.1
CH-3	16.82	100.100	13.925	87.865	146.332	23.947	118.060	0.00606	-0.7019	21.5902	28.0	11.0	64.1
CH-3	15.69	102.050	13.825	89.655	139.277	23.597	112.686	0.00524	-0.6221	19.4324	28.0	11.0	64.1
CH-3	15.19	102.400	14.950	89.082	143.925	23.936	116.129	0.00573	-0.6747	20.9705	28.0	11.0	64.1
CH-3	15.16	97.325	13.800	85.523	146.286	24.019	117.955	0.00601	-0.7014	21.6621	28.0	11.0	64.1
CH-3	15.73	103.025	14.675	89.841	148.038	24.143	119.248	0.00619	-0.7212	22.2486	28.0	11.0	64.1
CH-3	16.32	104.575	14.525	91.312	150.629	24.397	121.087	0.00641	-0.7505	23.2134	28.0	11.0	64.1
CH-3	14.52	100.175	14.600	87.413	146.746	24.029	118.316	0.00607	-0.7066	21.7881	28.0	11.0	64.1
CH-3	14.37	106.025	14.975	92.216	148.179	24.138	119.366	0.00621	-0.7228	22.2790	28.0	11.0	64.1
CH-3	17.60	107.700	14.725	93.877	146.254	24.050	117.899	0.00597	-0.7010	21.7280	28.0	11.0	64.1
CH-3	19.84	122.775	18.425	103.673	147.743	24.063	119.087	0.00617	-0.7179	22.1359	28.0	11.0	64.1
CH-3	15.67	121.875	18.175	103.131	152.731	24.319	122.854	0.00671	-0.7743	23.6963	28.0	11.0	64.1
CH-3	18.01	122.125	19.200	102.454	157.432	24.576	126.375	0.00627	-0.7318	22.5706	28.0	11.0	64.1
CH-3	18.87	118.375	19.325	99.204	138.803	23.457	112.430	0.00523	-0.6168	19.1679	28.0	11.0	64.1
CH-3	18.31	123.300	17.950	104.536	159.461	24.885	127.686	0.00734	-0.8504	26.1071	28.0	11.0	64.1
CH-3	19.05	122.850	18.350	103.802	159.439	24.906	127.646	0.00733	-0.8501	26.1184	28.0	11.0	64.1
CH-3	21.64	123.725	18.800	104.146	155.568	24.630	124.824	0.00695	-0.8064	24.7941	28.0	11.0	64.1
CH-3	17.58	117.075	18.500	98.797	151.191	24.353	121.582	0.00680	-0.7915	24.3901	28.0	11.0	64.1
CH-3	17.48	123.025	17.850	104.391	153.841	24.533	123.534	0.00677	-0.7868	24.2213	28.0	11.0	64.1
CH-3	16.66	123.550	18.450	104.306	158.495	24.798	127.001	0.00726	-0.8395	25.7335	28.0	11.0	64.1
CH-3	17.82	122.725	18.875	103.239	155.340	24.647	124.624	0.00691	-0.8038	24.7524	28.0	11.0	64.1
CH-3	19.00	121.000	19.525	101.234	147.469	24.160	118.774	0.00607	-0.7148	22.1864	28.0	11.0	64.1
SC-3	10.77	126.250	10.075	114.695	143.208	23.603	115.861	0.00578	-0.6666	20.4234	8.0	13.0	55.4
SC-3	9.83	122.000	10.275	110.633	152.150	24.056	122.646	0.00680	-0.7677	23.1834	8.0	13.0	55.4
SC-3	9.60	125.850	10.475	113.917	150.423	23.960	121.349	0.00661	-0.7482	22.6293	8.0	13.0	55.4
SC-3	9.97	125.375	10.075	113.900	142.069	23.478	115.057	0.00569	-0.6537	19.9994	8.0	13.0	55.4
SC-3	9.90	131.275	9.025	120.408	141.858	23.526	114.841	0.00564	-0.6513	19.9854	8.0	13.0	55.4
SC-3	9.85	127.700	10.000	116.091	149.460	23.886	120.643	0.00652	-0.7373	22.3002	8.0	13.0	55.4
SC-3	9.79	127.725	10.075	116.035	149.652	23.936	120.749	0.00652	-0.7395	22.4059	8.0	13.0	55.4
SC-3	10.31	127.850	10.300	115.911	141.002	23.361	114.300	0.00559	-0.6416	19.6198	8.0	13.0	55.4
SC-3	9.61	131.175	9.050	120.289	144.403	23.607	116.824	0.00595	-0.6801	20.7222	8.0	13.0	55.4
SC-3	10.39	127.775	9.875	116.291	149.319	23.938	120.479	0.00647	-0.7357	22.3258	8.0	13.0	55.4
SC-3	10.52	127.575	9.675	116.321	150.715	23.990	121.554	0.00664	-0.7515	22.7419	8.0	13.0	55.4
SC-3	9.81	127.575	9.775	116.215	140.508	23.396	113.868	0.00550	-0.6361	19.5279	8.0	13.0	55.4
SC-3	12.34	128.050	12.650	113.671	133.635	22.668	108.941	0.00491	-0.5583	16.9923	8.0	13.0	55.4
SC-3	13.18	129.075	13.750	113.473	140.261	23.027	114.008	0.00566	-0.6333	19.0464	8.0	13.0	55.4
SC-3	12.94	129.975	12.600	115.431	138.289	22.742	112.666	0.00554	-0.6110	18.2003	8.0	13.0	55.4
SC-3	11.98	123.700	12.050	110.397	135.813	23.039	110.382	0.00502	-0.5829	17.9603	8.0	13.0	55.4
SC-3	12.49	131.575	12.025	117.451	139.996	23.202	113.631	0.00552	-0.6303	19.1614	8.0	13.0	55.4
SC-3	13.90	130.625	12.400	116.214	142.825	23.429	115.714	0.00580	-0.6623	20.1234	8.0	13.0	55.4
SC-3	12.58	131.800	12.225	117.443	147.589	23.744	119.270	0.00632	-0.7161	21.6665	8.0	13.0	55.4
SC-3	12.25	130.075	12.225	115.906	129.354	22.129	105.916	0.00450	-0.5099	15.4939	8.0	13.0	55.4
SC-3	12.49	130.050	11.875	116.246	140.703	23.026	114.368	0.00570	-0.6382	19.1141	8.0	13.0	55.4
SC-3	12.86	127.700	12.800	113.209	135.863	22.528	110.883	0.00526	-0.5835	17.3673	8.0	13.0	55.4
SC-3	12.44	128.475	12.525	114.175	145.996	23.548	118.170	0.00620	-0.6981	21.0368	8.0	13.0	55.4
SC-3	13.40	128.400	12.100	114.541	133.471	23.005	108.508	0.00471	-0.5565	17.3399	8.0	13.0	55.4
SC-3	7.80	112.975	8.450	104.172	121.113	20.369	100.618	0.00412	-0.4167	11.6562	8.0	13.0	55.4
SC-3	8.97	115.175	8.100	106.545	122.197	20.582	101.339	0.00418	-0.4289	12.1281	8.0	13.0	55.4
SC-3	9.05	112.450	7.350	104.751	122.903	20.728	101.802	0.00405	-0.4185	11.8810	8.0	13.0	55.4
SC-3	9.01	119.500	8.425	110.214	121.884	21.132	100.621	0.00389	-0.4254	12.6145	8.0	13.0	55.4
SC-3	8.06	116.225	8.475	107.145	124.074	20.823	102.691	0.00436	-0.4502	12.7657	8.0	13.0	55.4
SC-3	9.36	118.800	8.225	109.771	128.496	21.316	105.919	0.00477	-0.5002	14.3217	8.0	13.0	55.4
SC-3	8.26	113.350	8.050	104.905	126.738	20.964	104.774	0.00474	-0.4823	13.5148	8.0	13.0	55.4
SC-3	10.56	123.075	8.550	113.381	126.980	21.621	104.407	0.00440	-0.4830	14.2925	8.0	13.0	55.4
SC-3	9.27	117.225	7.750	108.794	125.058	21.014	103.341	0.00441	-0.4613	13.1987	8.0	13.0	55.4
SC-3	8.05	120.175	8.025	111.247	126.574	21.141	104.485	0.00436	-0.4542	12.9495	8.0	13.0	55.4
SC-3	9.20	116.350	7.175	108.561	125.207	20.853	103.603	0.00449	-0.4630	13.0797	8.0	13.0	55.4
SC-3	9.48	125.000	7.625	116.144	127.852	21.525	105.206	0.00457	-0.4929	14.4026	8.0	13.0	55.4

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CL-3	33.17	91.475	30.225	70.244	149.399	24.111	120.375	0.00638	-0.7366	22.5663	49.0	24.0	95.1
CL-3	33.05	90.775	28.675	70.546	142.553	23.632	115.304	0.00564	-0.6592	20.3717	49.0	24.0	95.1
CL-3	32.67	90.625	32.525	68.383	153.780	24.615	123.405	0.00672	-0.7862	24.3119	49.0	24.0	95.1
CL-3	32.79	89.375	31.475	67.979	153.217	24.573	122.994	0.00667	-0.7798	24.0978	49.0	24.0	95.1
CL-3	29.93	93.525	32.075	70.812	152.025	24.487	122.121	0.00656	-0.7663	23.6837	49.0	24.0	95.1
CL-3	33.55	92.975	27.950	72.665	144.126	23.983	116.247	0.00573	-0.6770	21.1421	49.0	24.0	95.1
CL-3	33.19	92.250	32.375	69.688	148.127	24.274	119.194	0.00613	-0.7222	22.4524	49.0	24.0	95.1
CL-3	33.11	92.375	31.725	70.127	153.644	24.585	123.325	0.00672	-0.7846	24.2266	49.0	24.0	95.1
CL-3	32.68	94.775	33.125	71.192	157.930	24.872	126.474	0.00715	-0.8331	25.6905	49.0	24.0	95.1
CL-3	34.03	95.600	27.375	75.054	142.505	23.842	115.070	0.00556	-0.6586	20.5406	49.0	24.0	95.1
CL-3	28.63	84.750	23.975	68.361	135.910	23.070	110.433	0.00503	-0.5840	18.0118	49.0	24.0	95.1
CL-3	26.71	85.725	26.725	67.646	139.721	23.204	113.406	0.00549	-0.6271	19.0768	49.0	24.0	95.1
CL-3	30.00	84.850	23.675	68.607	136.052	22.886	110.714	0.00512	-0.5856	17.8282	49.0	24.0	95.1
CL-3	25.10	86.800	23.975	70.014	137.743	23.236	111.772	0.00521	-0.6048	18.6423	49.0	24.0	95.1
CL-3	23.93	88.775	23.750	71.737	142.058	23.870	114.684	0.00546	-0.6536	20.5664	49.0	24.0	95.1
CL-3	27.50	88.875	25.850	70.620	144.762	23.731	116.998	0.00593	-0.6842	20.9469	49.0	24.0	95.1
CL-3	26.88	93.800	22.925	76.307	140.822	23.211	114.293	0.00562	-0.6396	19.3785	49.0	24.0	95.1
CL-3	27.62	92.450	24.200	74.436	142.228	23.637	115.037	0.00564	-0.6555	20.2114	49.0	24.0	95.1
CL-3	24.88	95.175	21.575	78.285	134.737	22.865	109.663	0.00493	-0.5708	17.5024	49.0	24.0	95.1
CL-3	26.35	94.450	26.150	74.871	144.777	23.525	117.204	0.00601	-0.6843	20.7278	49.0	24.0	95.1
CL-3	29.85	96.600	22.650	78.761	140.808	23.248	114.247	0.00565	-0.6432	19.5042	49.0	24.0	95.1
CL-3	26.28	94.575	22.700	77.078	138.432	23.145	112.413	0.00531	-0.6126	18.7349	49.0	24.0	95.1
CL-3	29.99	89.275	24.825	71.520	131.207	22.883	106.774	0.00446	-0.5309	16.6481	49.0	24.0	95.1
CL-3	30.77	91.675	25.525	73.033	152.216	24.458	122.303	0.00660	-0.7685	23.7155	49.0	24.0	95.1
CL-3	31.33	89.400	23.825	72.199	145.571	24.020	117.377	0.00591	-0.6933	21.5063	49.0	24.0	95.1
CL-3	30.01	94.300	25.350	75.229	147.846	24.068	119.166	0.00615	-0.7190	22.2636	49.0	24.0	95.1
CL-3	28.25	91.475	27.050	71.999	141.030	23.788	113.929	0.00541	-0.6420	20.0829	49.0	24.0	95.1
CL-3	30.88	93.525	27.275	73.483	159.081	24.834	127.434	0.00731	-0.8461	25.9783	49.0	24.0	95.1
CL-3	29.98	93.425	24.500	75.040	146.143	24.120	117.743	0.00592	-0.6998	21.7823	49.0	24.0	95.1
CL-3	31.86	101.125	26.850	79.720	148.206	24.208	119.321	0.00608	-0.7145	22.1604	49.0	24.0	95.1
CL-3	29.80	92.875	28.325	72.375	143.854	23.949	116.059	0.00570	-0.6739	20.9895	49.0	24.0	95.1
CL-3	30.25	94.375	27.925	73.774	157.001	24.745	125.858	0.00708	-0.8226	25.2882	49.0	24.0	95.1
CL-3	30.30	92.975	23.550	75.253	147.762	24.235	118.937	0.00609	-0.7181	22.3157	49.0	24.0	95.1
CL-3	31.35	101.475	29.375	78.435	139.433	23.466	112.932	0.00528	-0.6239	19.3876	49.0	24.0	95.1
SC-4	11.61	121.350	11.550	108.785	137.029	23.034	111.374	0.00522	-0.5967	18.2420	19.0	12.0	40.0
SC-4	11.61	125.850	9.800	114.617	140.769	23.392	114.082	0.00555	-0.6390	19.5811	19.0	12.0	40.0
SC-4	11.86	118.100	8.000	109.352	142.877	23.395	115.789	0.00585	-0.6628	20.0801	19.0	12.0	40.0
SC-4	13.59	126.625	11.850	113.210	136.804	23.183	111.058	0.00510	-0.5942	18.3554	19.0	12.0	40.0
SC-4	11.59	125.350	11.350	112.573	137.024	23.143	111.272	0.00516	-0.5966	18.3600	19.0	12.0	40.0
SC-4	10.82	126.400	9.875	115.040	143.449	23.673	115.990	0.00579	-0.6693	20.5572	19.0	12.0	40.0
SC-4	10.47	121.775	8.200	112.546	142.593	23.414	115.541	0.00581	-0.6596	20.0401	19.0	12.0	40.0
SC-4	13.51	128.875	11.975	115.093	133.932	22.998	108.889	0.00480	-0.5617	17.4396	19.0	12.0	40.0
SC-4	10.24	124.250	11.625	111.310	138.984	23.304	112.716	0.00534	-0.6188	19.0396	19.0	12.0	40.0
SC-4	8.74	125.725	10.575	113.701	143.997	23.651	116.455	0.00586	-0.6755	20.6638	19.0	12.0	40.0
SC-4	7.71	120.575	8.700	110.925	147.990	23.805	119.534	0.00635	-0.7207	21.8377	19.0	12.0	40.0
SC-4	12.63	126.275	11.875	112.872	137.730	23.342	111.665	0.00515	-0.6046	18.7502	19.0	12.0	40.0
SC-4	7.61	105.975	8.400	97.763	132.768	22.558	108.331	0.00483	-0.5485	16.6682	19.0	12.0	40.0
SC-4	8.38	112.450	10.250	101.995	138.304	23.060	112.388	0.00539	-0.6111	18.5705	19.0	12.0	40.0
SC-4	14.23	110.075	10.025	100.045	138.109	22.872	112.400	0.00545	-0.6089	18.3167	19.0	12.0	40.0
SC-4	12.76	105.150	7.050	98.225	127.725	22.168	104.549	0.00431	-0.4915	15.0435	19.0	12.0	40.0
SC-4	11.45	110.725	8.800	101.769	136.545	22.889	111.112	0.00519	-0.5912	17.9512	19.0	12.0	40.0
SC-4	8.63	114.800	10.175	104.198	140.298	22.876	114.178	0.00572	-0.6337	18.8449	19.0	12.0	40.0
SC-4	10.86	114.125	10.300	103.468	135.341	22.287	110.675	0.00530	-0.5776	16.9849	19.0	12.0	40.0
SC-4	11.00	108.900	7.450	101.349	127.510	22.085	104.444	0.00404	-0.4710	14.5525	19.0	12.0	40.0
SC-4	8.41	112.550	9.050	103.210	136.134	22.563	111.073	0.00527	-0.5866	17.4809	19.0	12.0	40.0
SC-4	8.10	115.425	10.300	104.646	139.287	22.862	113.369	0.00558	-0.6222	18.5813	19.0	12.0	40.0
SC-4	15.56	114.975	10.200	104.333	139.525	22.775	113.644	0.00583	-0.6397	18.8835	19.0	12.0	40.0
SC-4	10.22	110.050	7.550	102.325	129.244	22.219	105.748	0.00445	-0.5087	15.4654	19.0	12.0	40.0
SC-4	15.91	124.575	15.375	107.974	126.964	20.226	105.605	0.00505	-0.4829	12.9331	19.0	12.0	40.0
SC-4	16.73	125.575	15.200	109.006	144.799	23.182	117.549	0.00621	-0.6846	20.3233	19.0	12.0	40.0
SC-4	16.73	126.375	15.625	109.297	140.492	23.106	114.123	0.00565	-0.6359	19.1841	19.0	12.0	40.0
SC-4	16.46	124.400	15.475	107.729	138.821	22.743	113.099	0.00559	-0.6170	18.3555	19.0	12.0	40.0
SC-4	17.13	122.100	16.650	104.672	134.434	21.641	110.517	0.00542	-0.5674	16.3441	19.0	12.0	40.0
SC-4	15.03	121.625	15.000	105.761	150.126	23.619	121.443	0.00674	-0.7448	22.1684	19.0	12.0	40.0
SC-4	16.87	123.725	16.350	106.339	138.436	22.580	112.935	0.00560	-0.6126	18.0698	19.0	12.0	40.0
SC-4	17.25	124.525	15.125	108.165	138.830	23.061	112.814	0.00541	-0.6171	18.7136	19.0	12.0	40.0

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
CH-ERDC	9.83	103.975	8.600	95.741	129.740	22.329	106.058	0.00449	-0.5143	15.7072	11.0	14.0	32.1
CH-ERDC	15.66	112.300	12.200	100.089	137.578	22.626	112.193	0.00545	-0.6029	17.9296	11.0	14.0	32.1
CH-ERDC	11.69	108.800	10.900	98.106	130.020	22.038	106.541	0.00466	-0.5174	15.4404	11.0	14.0	32.1
CH-ERDC	16.12	118.200	13.525	104.118	127.147	22.017	104.205	0.00427	-0.4849	14.7492	11.0	14.0	32.1
CH-ERDC	9.05	110.625	8.950	101.537	132.875	22.384	108.572	0.00489	-0.5497	16.5070	11.0	14.0	32.1
CH-ERDC	12.50	117.150	12.050	104.552	141.936	23.028	115.369	0.00586	-0.6522	19.4277	11.0	14.0	32.1
CH-ERDC	11.14	115.475	11.450	103.611	140.354	23.263	113.865	0.00556	-0.6343	19.3180	11.0	14.0	32.1
CH-ERDC	17.14	114.800	13.500	101.145	131.148	22.375	107.169	0.00467	-0.5302	16.0832	11.0	14.0	32.1
CH-ERDC	10.95	112.700	9.625	102.805	139.760	23.249	113.396	0.00548	-0.6276	19.1467	11.0	14.0	32.1
CH-ERDC	12.03	118.575	12.275	105.611	140.420	22.892	114.264	0.00571	-0.6351	18.8992	11.0	14.0	32.1
CH-ERDC	14.32	118.450	11.825	105.924	141.009	23.463	114.212	0.00555	-0.6417	19.6975	11.0	14.0	32.1
CH-ERDC	14.17	118.575	10.850	106.969	129.914	22.369	106.166	0.00451	-0.5162	15.7878	11.0	14.0	32.1
CH-ERDC	7.65	102.800	7.325	95.784	125.196	21.077	103.402	0.00438	-0.4629	13.2941	11.0	14.0	32.1
CH-ERDC	8.00	103.925	8.275	95.982	125.079	21.004	103.368	0.00439	-0.4615	13.1884	11.0	14.0	32.1
CH-ERDC	8.18	110.475	7.750	102.529	136.672	22.699	111.387	0.00518	-0.5927	18.0530	11.0	14.0	32.1
CH-ERDC	9.03	105.325	8.200	97.343	127.939	21.989	104.878	0.00437	-0.4939	14.9015	11.0	14.0	32.1
CH-ERDC	8.27	103.125	7.700	95.752	131.467	21.765	107.968	0.00498	-0.5338	15.4822	11.0	14.0	32.1
CH-ERDC	8.45	105.325	8.650	96.940	133.350	22.333	109.006	0.00498	-0.5551	16.5602	11.0	14.0	32.1
CH-ERDC	8.33	110.850	8.000	102.639	128.095	22.003	104.994	0.00437	-0.4957	14.9577	11.0	14.0	32.1
CH-ERDC	9.11	107.525	8.750	98.874	130.067	21.832	106.759	0.00474	-0.5180	15.2334	11.0	14.0	32.1
CH-ERDC	7.94	105.850	8.300	97.738	133.164	22.021	109.131	0.00509	-0.5530	16.1671	11.0	14.0	32.1
CH-ERDC	8.87	107.875	9.100	98.877	137.432	22.487	112.202	0.00549	-0.6013	17.7026	11.0	14.0	32.1
CH-ERDC	8.78	111.050	8.700	102.162	132.183	22.161	108.204	0.00488	-0.5419	16.0957	11.0	14.0	32.1
CH-ERDC	14.90	110.225	15.975	95.042	141.127	23.492	114.280	0.00555	-0.6431	19.7579	11.0	14.0	32.1
CH-ERDC	14.93	114.475	17.750	97.219	154.196	24.221	124.130	0.00699	-0.7909	23.9231	11.0	14.0	32.1
CH-ERDC	14.43	114.425	17.250	97.591	142.064	22.936	115.559	0.00592	-0.6536	19.3439	11.0	14.0	32.1
CH-ERDC	15.50	114.550	16.100	98.665	146.236	23.808	118.115	0.00611	-0.7008	21.4191	11.0	14.0	32.1
CH-ERDC	15.11	115.375	16.500	99.034	140.679	23.488	113.921	0.00549	-0.6380	19.6501	11.0	14.0	32.1
CH-ERDC	14.15	116.475	17.100	99.466	152.893	24.251	123.052	0.00679	-0.7761	23.6162	11.0	14.0	32.1
CH-ERDC	13.58	117.525	17.250	100.235	155.370	24.371	124.925	0.00707	-0.8041	24.3869	11.0	14.0	32.1
CH-ERDC	13.56	117.375	15.900	101.273	149.964	24.040	120.900	0.00650	-0.7430	22.6238	11.0	14.0	32.1
CH-ERDC	13.56	114.925	16.875	98.332	141.847	23.215	115.122	0.00575	-0.6512	19.6178	11.0	14.0	32.1
CH-ERDC	14.48	115.600	17.350	98.509	155.466	24.286	125.087	0.00711	-0.8052	24.3136	11.0	14.0	32.1
CH-ERDC	14.36	115.775	17.050	98.911	150.815	23.723	121.898	0.00675	-0.7526	22.4389	11.0	14.0	32.1
CH-ERDC	14.60	116.600	17.325	99.382	148.696	24.011	119.905	0.00633	-0.7287	22.2874	11.0	14.0	32.1
MH	7.98	104.650	7.075	97.735	124.282	20.944	102.760	0.00428	-0.4525	12.9436	18.0	10.0	49.6
MH	7.84	104.875	7.525	97.535	141.320	22.963	114.929	0.00584	-0.6452	19.1929	18.0	10.0	49.6
MH	7.74	105.575	7.350	98.347	134.267	22.532	109.578	0.00505	-0.5655	17.0041	18.0	10.0	49.6
MH	7.78	105.267	6.600	98.749	134.415	22.763	109.492	0.00496	-0.5671	17.3119	18.0	10.0	49.6
MH	7.57	108.075	6.925	101.076	135.112	22.305	110.472	0.00525	-0.5750	16.9426	18.0	10.0	49.6
MH	7.88	108.025	7.300	100.676	142.404	22.843	115.924	0.00602	-0.6575	19.3154	18.0	10.0	49.6
MH	7.43	109.800	6.750	102.857	136.161	22.329	111.307	0.00537	-0.5869	17.2300	18.0	10.0	49.6
MH	7.55	108.650	7.150	101.400	134.863	22.591	110.011	0.00507	-0.5722	17.2393	18.0	10.0	49.6
MH	7.41	112.050	6.825	104.891	138.276	22.721	112.676	0.00550	-0.6108	18.1761	18.0	10.0	49.6
MH	7.78	110.825	7.725	102.878	146.815	23.308	119.064	0.00641	-0.7074	20.9502	18.0	10.0	49.6
MH	7.18	112.425	6.725	105.341	140.358	22.702	114.389	0.00579	-0.6343	18.6600	18.0	10.0	49.6
MH	7.39	110.950	7.450	103.257	139.191	23.286	112.901	0.00538	-0.6212	19.0729	18.0	10.0	49.6
MH	9.19	104.850	7.950	97.128	140.762	23.166	114.287	0.00565	-0.6389	19.2938	18.0	10.0	49.6
MH	8.82	106.675	8.350	98.454	139.709	22.753	113.813	0.00568	-0.6270	18.5581	18.0	10.0	49.6
MH	9.28	104.125	7.950	96.457	139.762	23.209	113.435	0.00550	-0.6276	19.0962	18.0	10.0	49.6
MH	8.59	110.300	8.700	101.472	134.885	22.903	109.749	0.00494	-0.5724	17.5864	18.0	10.0	49.6
MH	8.68	107.975	8.375	99.631	143.608	23.510	116.273	0.00587	-0.6711	20.4151	18.0	10.0	49.6
MH	8.29	109.325	8.975	100.321	150.038	23.962	121.036	0.00656	-0.7438	22.5410	18.0	10.0	49.6
MH	7.52	106.500	8.400	98.247	145.077	23.317	117.646	0.00616	-0.6877	20.5324	18.0	10.0	49.6
MH	8.72	112.500	8.525	103.663	150.641	24.060	121.426	0.00658	-0.7507	22.8131	18.0	10.0	49.6
MH	9.92	113.850	8.500	104.931	153.580	24.168	123.687	0.00694	-0.7839	23.6873	18.0	10.0	49.6
MH	9.08	111.475	7.975	103.241	149.458	23.942	120.587	0.00641	-0.7284	22.1080	18.0	10.0	49.6
MH	8.13	115.650	9.000	106.101	145.079	23.799	117.189	0.00594	-0.6877	21.1387	18.0	10.0	49.6
MH	14.93	121.425	13.025	107.432	143.687	23.725	116.135	0.00576	-0.6720	20.7501	18.0	10.0	49.6
MH	13.63	128.700	13.725	113.168	151.657	24.179	122.127	0.00663	-0.7621	23.2434	18.0	10.0	49.6
MH	13.08	126.025	14.475	110.090	154.361	24.510	123.975	0.00685	-0.7927	24.3223	18.0	10.0	49.6
MH	14.53	121.625	13.425	107.229	141.922	23.416	114.995	0.00568	-0.6520	19.8943	18.0	10.0	49.6
MH	14.12	120.400	12.750	106.785	143.362	23.779	115.821	0.00570	-0.6683	20.7016	18.0	10.0	49.6
MH	13.95	128.025	13.975	112.327	148.896	23.849	120.224	0.00640	-0.7309	22.1637	18.0	10.0	49.6
MH	12.88	126.350	14.600	110.253	157.497	24.727	126.274	0.00716	-0.8282	25.3893	18.0	10.0	49.6
MH	13.32	121.925	14.000	106.952	138.489	23.302	112.317	0.00524	-0.6132	18.9277	18.0	10.0	49.6
MH	13.17	123.425	12.800	109.419	145.156	23.894	117.162	0.00589	-0.6886	21.2890	18.0	10.0	49.6
MH	13.79	129.625	14.100	113.606	157.798	24.621	126.622	0.00723	-0.8316	25.3757	18.0	10.0	49.6
MH	13.93	127.525	14.300	111.570	159.943	24.824	128.135	0.00744	-0.8559	26.1432	18.0	10.0	49.6
MH	13.09	125.125	13.650	110.097	143.632	23.799	116.020	0.00575	-0.6714	20.7637	18.0	10.0	49.6

Soil	Oven	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
ID	Moisture	γ_w	%w	γ_d	γ_w	%w	γ_d						
ML	8.13	101.450	7.775	94.131	122.398	21.637	100.626	0.00377	-0.4312	13.2366	24.0	12.0	35.1
ML	7.50	101.175	8.000	93.681	120.350	21.342	99.183	0.00359	-0.4081	12.4615	24.0	12.0	35.1
ML	6.89	103.325	7.875	95.782	122.199	21.321	100.724	0.00390	-0.4290	12.8657	24.0	12.0	35.1
ML	8.01	104.425	7.600	97.049	122.881	21.422	101.202	0.00394	-0.4367	13.1238	24.0	12.0	35.1
ML	8.08	105.450	7.600	98.002	127.085	21.885	104.266	0.00434	-0.4842	14.5869	24.0	12.0	35.1
ML	7.59	101.975	7.100	95.215	124.764	21.851	102.391	0.00402	-0.4580	14.0054	24.0	12.0	35.1
ML	7.59	104.550	7.900	96.895	126.428	21.978	103.648	0.00423	-0.4768	14.5840	24.0	12.0	35.1
ML	7.70	105.025	7.650	97.562	124.709	21.496	102.645	0.00418	-0.4574	13.6239	24.0	12.0	35.1
ML	7.89	107.150	8.550	98.710	127.341	21.812	104.539	0.00442	-0.4871	14.5737	24.0	12.0	35.1
ML	8.05	103.100	7.350	96.041	123.659	21.752	101.566	0.00390	-0.4455	13.6476	24.0	12.0	35.1
ML	13.31	126.650	14.525	110.587	138.572	23.335	112.355	0.00527	-0.6142	18.9597	24.0	12.0	35.1
ML	12.14	127.625	15.200	110.786	145.451	23.754	117.533	0.00603	-0.6920	21.1363	24.0	12.0	35.1
ML	12.08	128.150	14.575	111.848	146.991	23.704	118.824	0.00626	-0.7094	21.4672	24.0	12.0	35.1
ML	12.13	119.750	13.750	105.275	135.502	23.103	110.072	0.00495	-0.5794	17.9484	24.0	12.0	35.1
ML	10.11	118.675	15.675	102.593	145.035	23.706	117.242	0.00600	-0.6872	20.9804	24.0	12.0	35.1
ML	13.28	119.650	16.475	102.726	146.560	23.810	118.375	0.00615	-0.7045	21.4795	24.0	12.0	35.1
ML	10.63	119.925	16.275	103.139	148.166	23.856	119.628	0.00634	-0.7227	21.9445	24.0	12.0	35.1
ML	11.79	115.925	16.525	99.485	144.563	23.723	116.844	0.00592	-0.6819	20.8911	24.0	12.0	35.1
ML	13.07	130.225	14.375	113.858	149.351	23.921	120.521	0.00646	-0.7361	22.3256	24.0	12.0	35.1
ML	12.82	131.400	14.600	114.660	145.355	23.657	117.547	0.00604	-0.6909	21.0218	24.0	12.0	35.1
ML	12.92	132.025	14.550	115.255	145.785	23.614	117.936	0.00613	-0.6957	21.0937	24.0	12.0	35.1
ML	12.79	127.600	14.475	111.465	143.795	23.445	116.486	0.00589	-0.6732	20.4742	24.0	12.0	35.1
ML	14.09	123.800	16.725	106.061	129.750	21.867	106.469	0.00470	-0.5144	15.1998	24.0	12.0	35.1
ML	14.79	125.000	17.300	106.564	135.384	22.450	110.563	0.00527	-0.5781	17.1848	24.0	12.0	35.1
ML	14.37	118.925	15.875	102.632	130.634	22.061	107.023	0.00485	-0.5244	15.6198	24.0	12.0	35.1
ML	12.04	122.975	14.575	107.331	137.668	23.091	111.843	0.00526	-0.6039	18.4470	24.0	12.0	35.1
ML	13.46	121.275	15.725	104.796	133.832	22.715	109.060	0.00494	-0.5605	17.0945	24.0	12.0	35.1
ML	14.56	117.250	17.475	99.808	130.671	22.322	106.825	0.00431	-0.4923	15.0243	24.0	12.0	35.1
ML	15.16	116.275	17.225	99.190	134.543	22.733	109.623	0.00504	-0.5686	17.2899	24.0	12.0	35.1
ML	11.76	123.450	15.000	107.348	135.397	22.784	110.273	0.00506	-0.5782	17.5524	24.0	12.0	35.1
SP	15.67	101.225	16.675	86.758	140.294	23.427	113.665	0.00552	-0.6336	19.5222	27.0	14.0	61.8
SP	16.55	99.775	15.575	86.329	132.658	22.755	108.067	0.00474	-0.5473	16.8542	27.0	14.0	61.8
SP	13.60	95.475	15.075	82.968	130.381	22.587	106.358	0.00450	-0.5215	16.1236	27.0	14.0	61.8
SP	14.96	97.900	14.975	85.149	134.954	22.963	109.751	0.00499	-0.5732	17.6503	27.0	14.0	61.8
SP	13.94	103.425	15.625	89.449	133.160	22.863	108.381	0.00475	-0.5529	17.1104	27.0	14.0	61.8
SP	12.31	101.725	15.425	88.131	137.380	23.018	111.675	0.00528	-0.6007	18.3041	27.0	14.0	61.8
SP	12.49	98.500	15.225	85.485	134.752	22.822	109.714	0.00499	-0.5710	17.4511	27.0	14.0	61.8
SP	10.90	102.750	14.625	89.640	132.285	22.762	107.757	0.00469	-0.5430	16.7782	27.0	14.0	61.8
SP	14.06	102.575	15.500	88.810	135.521	22.938	110.236	0.00503	-0.5796	17.7943	27.0	14.0	61.8
SP	13.22	102.775	16.025	88.580	144.351	23.519	116.865	0.00600	-0.6795	20.6133	27.0	14.0	61.8
SP	13.41	101.275	15.150	87.950	130.627	22.379	106.740	0.00462	-0.5243	15.9652	27.0	14.0	61.8
SP	13.49	102.900	14.800	89.634	130.427	22.686	106.310	0.00445	-0.5220	16.2457	27.0	14.0	61.8
SP	19.99	117.225	20.150	97.566	141.851	23.512	114.848	0.00568	-0.6512	19.9675	27.0	14.0	61.8
SP	21.15	122.825	21.275	101.278	145.509	23.575	117.750	0.00611	-0.6926	20.9445	27.0	14.0	61.8
SP	19.56	117.700	19.825	98.227	142.665	23.578	115.445	0.00560	-0.6467	19.8124	27.0	14.0	61.8
SP	17.47	111.400	20.300	92.602	138.386	23.349	112.190	0.00525	-0.6120	18.9200	27.0	14.0	61.8
SP	20.02	119.825	16.075	103.231	142.569	23.391	115.542	0.00579	-0.6594	20.0003	27.0	14.0	61.8
SP	21.19	124.775	21.100	103.035	150.463	24.055	121.287	0.00658	-0.7486	22.7699	27.0	14.0	61.8
SP	19.22	118.975	20.250	98.940	144.841	23.702	117.089	0.00596	-0.6851	20.9328	27.0	14.0	61.8
SP	18.62	112.175	21.000	92.707	138.872	23.370	112.565	0.00530	-0.6175	19.0649	27.0	14.0	61.8
SP	20.61	122.000	20.000	101.667	146.649	23.648	118.602	0.00686	-0.7668	23.0602	27.0	14.0	61.8
SP	20.66	124.450	21.150	102.724	151.981	24.207	122.361	0.00671	-0.7658	23.3419	27.0	14.0	61.8
SP	19.03	121.875	19.500	101.987	144.469	23.672	116.817	0.00593	-0.6808	20.8006	27.0	14.0	61.8
SP	17.63	111.525	18.950	93.758	138.027	23.394	111.859	0.00518	-0.6080	18.8751	27.0	14.0	61.8
SP	18.37	123.975	19.525	103.723	149.476	23.972	120.572	0.00647	-0.7375	22.4291	27.0	14.0	61.8
SP	18.61	122.950	20.650	101.906	149.538	24.129	120.469	0.00642	-0.7382	22.6135	27.0	14.0	61.8
SP	17.65	123.075	19.750	102.777	147.960	23.975	119.347	0.00626	-0.7203	22.0297	27.0	14.0	61.8
SP	18.46	112.100	21.000	92.645	144.226	23.724	116.570	0.00588	-0.6781	20.8228	27.0	14.0	61.8
SP	18.35	124.750	20.050	103.915	144.673	23.437	117.204	0.00605	-0.6832	20.5652	27.0	14.0	61.8
SP	19.04	122.375	21.775	100.493	148.082	23.955	119.464	0.00643	-0.7394	22.6127	27.0	14.0	61.8
SP	18.05	123.825	20.450	102.802	152.747	24.235	122.950	0.00679	-0.7745	23.5554	27.0	14.0	61.8
SP	18.22	116.525	19.325	97.653	139.003	23.419	112.627	0.00528	-0.6190	19.1922	27.0	14.0	61.8
SP	18.83	122.175	21.225	100.784	145.757	23.775	117.760	0.00605	-0.6954	21.2793	27.0	14.0	61.8
SP	18.62	122.750	21.600	100.946	149.628	23.723	120.938	0.00638	-0.7133	21.2918	27.0	14.0	61.8
SP	19.18	121.325	21.525	99.835	150.259	24.115	121.065	0.00651	-0.7463	22.7820	27.0	14.0	61.8
SP	17.30	116.150	20.825	96.131	138.403	23.016	112.508	0.00535	-0.6122	18.5588	27.0	14.0	61.8

Soil ID	Oven Moisture	Nuclear Gauge			SDG			A	B	C	PI	PL	% Fines
		γ_w	%w	γ_d	γ_w	%w	γ_d						
SM	21.90	92.700	19.600	77.508	139.518	23.430	113.035	0.00539	-0.6249	19.2868	33.0	23.0	82.0
SM	30.02	89.625	21.175	73.963	137.690	23.387	111.592	0.00514	-0.6042	18.7998	33.0	23.0	82.0
SM	25.49	98.500	20.050	82.049	145.500	24.072	117.270	0.00586	-0.6925	21.6108	33.0	23.0	82.0
SM	25.73	96.475	19.975	80.413	147.760	24.064	119.100	0.00621	-0.7181	22.0937	33.0	23.0	82.0
SM	24.16	96.075	21.800	78.879	148.069	24.251	119.169	0.00615	-0.7216	22.3984	33.0	23.0	82.0
SM	23.56	92.725	21.175	76.522	143.160	23.820	115.620	0.00567	-0.6660	20.6996	33.0	23.0	82.0
SM	24.96	98.775	20.225	82.158	141.904	23.981	114.456	0.00543	-0.6518	20.5283	33.0	23.0	82.0
SM	21.94	99.725	22.800	81.209	158.024	25.159	126.259	0.00704	-0.8342	26.0625	33.0	23.0	82.0
SM	23.59	97.650	23.375	79.149	160.699	25.366	128.185	0.00729	-0.8644	27.0351	33.0	23.0	82.0
SM	23.14	94.800	21.075	78.299	142.110	23.818	114.774	0.00556	-0.6542	20.3922	33.0	23.0	82.0
SM	30.40	110.300	27.825	86.290	159.670	25.161	127.571	0.00722	-0.8528	26.5773	33.0	23.0	82.0
SM	31.21	114.525	28.025	89.455	156.404	24.903	125.220	0.00694	-0.8158	25.3350	33.0	23.0	82.0
SM	31.01	112.125	28.050	87.563	167.819	25.540	133.678	0.00811	-0.9449	29.1634	33.0	23.0	82.0
SM	30.62	115.075	27.125	90.521	153.875	24.744	123.352	0.00669	-0.7872	24.4842	33.0	23.0	82.0
SM	30.96	113.700	27.275	89.334	153.320	24.621	123.029	0.00666	-0.7809	24.2054	33.0	23.0	82.0
SM	29.71	115.075	27.525	90.237	155.177	24.812	124.328	0.00683	-0.8019	24.8883	33.0	23.0	82.0
SM	31.44	112.700	28.300	87.841	164.712	25.373	131.377	0.00780	-0.9098	28.1068	33.0	23.0	82.0
SM	31.44	114.400	26.325	90.560	156.017	24.985	124.829	0.00685	-0.8115	25.3414	33.0	23.0	82.0
SM	35.64	111.650	31.075	85.180	169.520	25.199	135.401	0.00855	-0.9642	29.1194	33.0	23.0	82.0
SM	37.56	110.875	31.600	84.252	167.056	24.804	133.854	0.00844	-0.9363	27.9644	33.0	23.0	82.0
SM	29.39	112.775	31.925	85.484	158.514	24.391	127.432	0.00751	-0.8397	25.2219	33.0	23.0	82.0
SM	32.55	113.225	30.850	86.530	147.665	23.547	119.521	0.00642	-0.7170	21.5629	33.0	23.0	82.0
SM	39.88	113.400	32.150	85.812	155.292	24.153	125.081	0.00718	-0.8032	24.1164	33.0	23.0	82.0
SM	33.78	110.150	31.150	83.988	158.112	24.219	127.285	0.00755	-0.8351	24.9107	33.0	23.0	82.0
SM	38.56	106.975	31.475	81.365	148.460	23.810	119.909	0.00640	-0.7260	22.0001	33.0	23.0	82.0
SM	36.79	112.025	30.950	85.548	147.408	23.955	118.920	0.00619	-0.7141	21.9176	33.0	23.0	82.0
SP-SC	16.86	120.825	13.425	106.524	139.624	23.590	112.974	0.00530	-0.6261	19.5121	22.0	14.0	64.9
SP-SC	17.22	119.725	14.475	104.586	153.108	24.368	123.108	0.00676	-0.7785	23.8125	22.0	14.0	64.9
SP-SC	16.71	121.975	14.100	106.902	157.661	24.718	126.414	0.00721	-0.8300	25.4177	22.0	14.0	64.9
SP-SC	16.47	118.550	13.900	104.083	135.993	23.264	110.327	0.00494	-0.5850	18.2454	22.0	14.0	64.9
SP-SC	15.97	113.675	15.400	98.505	138.768	23.537	112.330	0.00520	-0.6164	19.2354	22.0	14.0	64.9
SP-SC	17.42	111.200	16.250	95.656	157.120	24.704	125.994	0.00737	-0.8500	26.0281	22.0	14.0	64.9
SP-SC	16.52	117.650	15.725	101.663	155.766	24.605	125.008	0.00701	-0.8086	24.7817	22.0	14.0	64.9
SP-SC	18.19	110.425	15.875	95.297	139.081	23.553	112.569	0.00523	-0.6199	19.3350	22.0	14.0	64.9
SP-SC	17.75	114.325	15.300	99.154	141.456	23.781	114.280	0.00528	-0.6270	19.5807	22.0	14.0	64.9
SP-SC	16.20	113.000	17.250	96.375	154.962	24.614	124.354	0.00689	-0.7995	24.5980	22.0	14.0	64.9
SP-SC	15.87	117.175	16.200	100.839	154.129	24.509	123.790	0.00683	-0.7901	24.2465	22.0	14.0	64.9
SP-SC	14.94	112.025	15.675	96.845	138.262	23.491	111.962	0.00515	-0.6106	19.0638	22.0	14.0	64.9
SP-SC	20.27	114.800	18.750	96.674	144.106	23.897	116.311	0.00576	-0.6767	21.0123	22.0	14.0	64.9
SP-SC	21.29	119.025	19.300	99.769	157.508	24.648	126.363	0.00722	-0.8283	25.3009	22.0	14.0	64.9
SP-SC	21.85	117.975	17.700	100.234	150.296	24.218	120.993	0.00646	-0.7467	22.9354	22.0	14.0	64.9
SP-SC	20.65	119.600	17.450	101.831	140.003	23.596	113.274	0.00535	-0.6303	19.6029	22.0	14.0	64.9
SP-SC	19.88	117.775	19.175	98.825	153.649	24.477	123.435	0.00711	-0.8210	25.1943	22.0	14.0	64.9
SP-SC	19.61	120.075	18.975	100.925	153.464	24.502	123.262	0.00675	-0.7826	24.0729	22.0	14.0	64.9
SP-SC	18.92	119.675	18.200	101.248	150.681	24.300	121.223	0.00646	-0.7511	23.1399	22.0	14.0	64.9
SP-SC	24.36	116.075	18.475	97.974	139.942	23.515	113.300	0.00538	-0.6296	19.5015	22.0	14.0	64.9
SP-SC	17.20	119.050	17.675	101.168	141.577	23.042	115.064	0.00586	-0.6481	19.3426	22.0	14.0	64.9
SP-SC	12.84	121.775	19.700	101.734	143.824	23.088	116.847	0.00614	-0.6736	19.9558	22.0	14.0	64.9
SP-SC	19.67	122.450	18.300	103.508	144.149	23.544	116.679	0.00597	-0.6772	20.5684	22.0	14.0	64.9
SP-SC	20.10	120.800	16.225	103.936	133.792	22.583	109.145	0.00498	-0.5601	16.9447	22.0	14.0	64.9
SP-SC	24.48	119.750	23.250	97.160	153.240	24.499	123.085	0.00676	-0.7800	24.0129	22.0	14.0	64.9
SP-SC	24.91	118.300	23.750	95.596	154.070	24.247	124.003	0.00699	-0.7894	23.9280	22.0	14.0	64.9
SP-SC	24.91	118.475	22.475	96.734	152.693	24.050	123.090	0.00690	-0.7739	23.3200	22.0	14.0	64.9
SP-SC	24.24	121.175	22.200	99.161	147.512	23.798	119.156	0.00633	-0.7153	21.7149	22.0	14.0	64.9
SP-SC	23.34	111.675	21.000	92.293	138.490	23.185	112.424	0.00538	-0.6132	18.7960	22.0	14.0	64.9
SP-SC	24.12	116.650	20.575	96.745	143.294	22.940	116.555	0.00618	-0.6676	19.6484	22.0	14.0	64.9
SP-SC	24.67	120.075	18.575	101.265	146.907	23.668	118.792	0.00629	-0.7084	21.4183	22.0	14.0	64.9
SP-SC	23.84	116.425	20.125	96.920	145.332	23.538	117.642	0.00616	-0.6906	20.8619	22.0	14.0	64.9

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14. ABSTRACT

This report presents results from an evaluation of a non-nuclear soil moisture-density gauge, the Soil Density Gauge (SDG 200), tested on a series of 16 different fine-grained soils. If the results were successful, the device would serve as a replacement to the standard nuclear moisture-density gauge. Results from a standard nuclear moisture-density gauge were used for comparison. Results of the tests are presented and include comparisons of the dry densities obtained from the SDG and the nuclear gauge. Correlations between the two devices showed a strong dependence on plasticity characteristics to distinguish among soil types. The lack of internal calibration for fine soils demonstrated poor correlation between moisture conditions for a given soil. Similar to SDG studies on coarser soils, the proper response from the SDG for fine-grained soils requires calibration of the dry density using at least one independent density sample obtained in the field with an alternative device such as a sand cone or a nuclear moisture-density gauge.

15. SUBJECT TERMS

Electrical impedance gauge
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Non-nuclear gauge

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